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ABSTRACT

Ten examples of innovative and outstanding middle school/junior high science programs are described. These programs were selected using state criteria and at least four independent reviewers. While Project Synthesis offered a desired state, these examples of excellence provided views of what is already a reality. The goals of an exemplary science program are provided along with the criteria for excellence. The programs described are: (1) "Seventh Grade Life Science"; (2) "The Rochester Science Program"; (3) "Laboratory at the Zoo"; (4) "PRIS2M"; (5) Environmental Physical Science"; (6) "9th Grade Earth Science"; (7) "5-8 General Science"; (8) "7th Grade Life Science and 8th Grade Earth Science"; (9) "Life Science, Earth and Physical Science, and Environmental Science"; and (10) "Field Science." A synthesis and critique of middle school/junior high science is presented. (KR)

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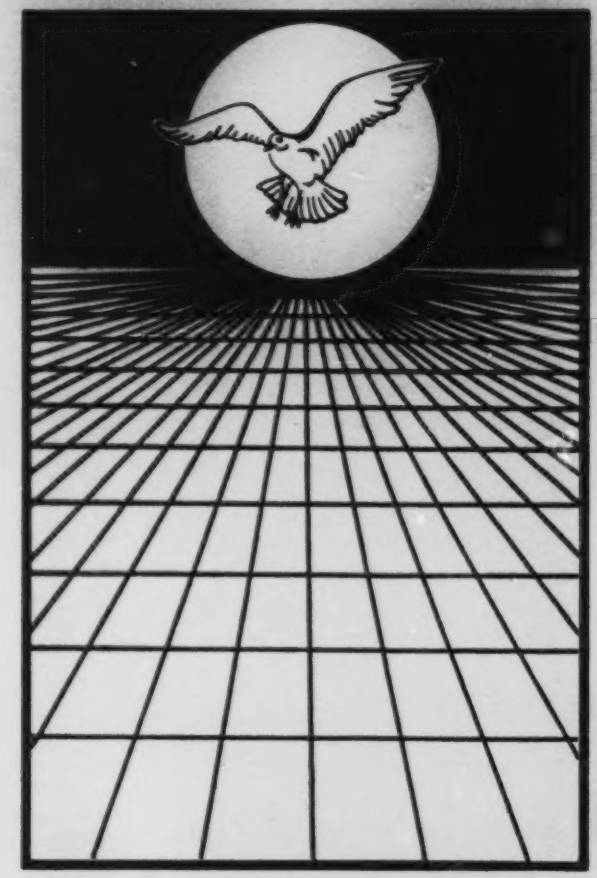
Volume 2 Number 2



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Middle School/ Junior High Science

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John Penick, Joseph Krajcik, Editors

FOCUS ON EXCELLENCE

Volume 2 Number 2

MIDDLE SCHOOL/JUNIOR HIGH SCIENCE

Edited by

John E. Penick and Joseph Krajcik

Science Education Center
University of Iowa
Iowa City, Iowa 52242

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Volume 2, describing programs from the 1983 search, includes separate issues describing programs in:

Physics
Middle School/Junior High
Non-School Settings

The **Focus On Excellence** series, Volume 1, included separate monographs on:

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Elementary Science
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TABLE OF CONTENTS

Chapter		Page
Prologue	**Excellent Middle/Junior High Science: The Search** John E. Penick University of Iowa	1
1.	**Excellence in Middle/Junior High School Science** Karen E. Reynolds, Nelson W. Pitotti, Steven J. Rakow, Thomas Thompson, and Sandy M. Wohl NSTA Task Force on Defining Excellence	4
2.	**Seventh Grade Life Science** Sam S. Chattin Scottsburg Junior High School	9
3.	**The Rochester Science Program** Marvin Mikesh, David Arlander, Sam Bailey, George Lueder, Howard Monnet, and Roger Nelson John Adams Junior High School	18
4.	**Laboratory at the Zoo** Kathaleen Burke, Anne Michael, and John Gallivan Buffalo Science Magnet School	28
5.	**PRIS2M** Benjamin Richardson, Douglas Seager, Joseph Accongio, Elena Brandes, and Robert Stevenson City School District of Rochester	37
6.	**Environmental Physical Science** Robert Ewart Lower Moreland Middle School	51
7.	**9th Grade Earth Science** Thomas P. Knorr, Sr. Pen Argyl Area Junior High School	60

8. **5-8 General Science**

John A. Bartley
E.T. Richardson Middle School 67

9. **7th Grade Life Science and 8th Grade Earth Science**

Jean McCaskill, Kyle Wilson, Denise Ralph,
Patti Martin, and Charles Mize
Owen Goodnight Junior High School 72

10. **Life Science, Earth and Physical Science, and Environmental Science**

Lynn L. Archibald, Randy Christensen, and
Michael D. Salvesen
South Cache Junior High School 76

11. **Field Science**

Terry Logue and Dan Van Burgh, Jr.
CY Junior High and Dean Morgan Junior High 83

12. **Middle School/Junior High Science: A Synthesis and Critique**

John E. Penick and Joseph Krajcik
Iowa City, Iowa 91

PROLOGUE: EXCELLENT MIDDLE SCHOOL/JUNIOR HIGH SCIENCE: THE SEARCH

By

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Junior high science, one of the last curriculum areas to undergo extensive revision, has always occupied a spot as the foundation of secondary science education. But, while we all know foundations must be carefully planned and well-constructed, science at the middle school/junior high is often neglected. We feel this should not be.

With this issue of the **Focus on Excellence** monograph series, the National Science Teachers Association hopes to offer you alternatives to many existing programs at this level. This monograph should provide inspiration, ideas, and resources as well as descriptions of innovative, successful science programs. The programs described in this monograph are certainly innovative, successful, and inspirational. And, equally as important, they are real, existing programs in schools like yours.

The NSTA Search For Excellence in Science Education began when Robert Yager, NSTA president for 1982-83, became a member of Project Synthesis, a project to analyze more than 2,000 pages of information from three NSF reports and from the National Assessment of Education Progress.

The twenty-three Synthesis researchers worked independently in small teams, each focusing on one aspect of science education; Elementary Science, Biology, Physical Science, Science/Technology/ Society, or Inquiry. A critical part of the synthesis and analysis was developing a description of an ideal or desired state for a focus area and then comparing the actual to the desired state. During the 1982 Search for Excellence, goals arising from the synthesis or desired state for each of the five focus areas were used as criteria for defining excellence in a school science program. These exemplary programs are described in the five issues of **Focus on Excellence** Volume 1. Volume 2, in addition to this issue, includes Physics Science in Non-School Settings. Volume 3 will include Energy Education, Chemistry, and Earth Science. Future years will

see a search for excellence in other school science areas, teacher education programs, and other aspects of science education. We feel strongly that this monograph series, **Focus on Excellence**, will play a needed and vital role in shaping science education practices and research of the future.

Goals and criteria for the 1983 search, reported in this volume of **Focus on Excellence**, were developed by several specifically appointed NSTA task forces. For the Middle/Junior High Search we are indebted to Karen Reynolds and the Middle/Junior High Science Task Force. Their report and criteria appear as Chapter One of this issue of **Focus on Excellence.**

Using these developed criteria, leading science educators (generally state science consultants) in each state were identified as chairs of committees to identify and nominate outstanding science programs in their respective states. Nominations were submitted to the task force for consideration at the national level. Thus, the state exemplars were passed on to another set of review committees and yet another selection process.

To aid in the selection process, all nominees were asked to fill out forms detailing information on demographics, texts used, and the nature of the school. The state nominees were given the specific criteria for excellence and asked to provide narrative information about five major aspects of their programs.

* Provide some information about the setting (community location, size, specific features, school science and organization);

* Describe the nature of the exemplary program (grade, level, class sizes, curriculum outline, learning activities, evaluation techniques);

* How the program exemplifies the 1983 criteria for SESE;

* How the exemplary program came into existence;

* What factors contribute to the success of the program and what is needed to keep it going.

While the Task Force and Project Synthesis proposed a desired state, these examples of excellence provide vivid views of what is already a reality. We hope you can profit through reading these descriptions by finding inspiration and a source of ideas. The programs described range in size from small schools to large, represent both urban and rural populations, and include schools from a broad geographical range. Schools with exemplary middle school/junior high science programs are found in communities of 1,000 to those with more than 200,000. Size of school or community does not seem to be a limiting factor in achieving excellence. Some schools have large budgets while others have almost no money at all.

Not surprisingly, teachers are the most significant factor. Teachers in all these programs are dynamic, thoughtful, young at heart, and eager to learn with their students. (If you are interested, see another monograph from NSTA, **Teachers in Exemplary Programs: How Do They Compare?**)

Chapter one describes criteria for excellence in middle school/junior high science education. Chapters two through eleven offer descriptions of

the ten programs selected as exemplary during the 1983 Search For Excellence. Chapter twelve is a synthesis and critique of the ideas found in these programs along with a number of generalizations and recommendations relating to excellence in science education for this age group.

These programs are all exemplary in various ways, but they certainly do not exhaust the supply of innovative and outstanding science education programs. Models of excellence do exist today. View these as examples of excellence, be prepared to find others, and create and nurture your own. We encourage you to contact people in any of these exemplary programs which may be applicable in your own school situation. You will find they have many materials, ideas, and aspirations which will delight you. And, you will also find they have a rationale, a philosophy, guiding them as they currently teach and continue to develop their programs. This rationale is a most significant factor in keeping their program's gradual evolution on the track they desire.

While you read, attempt to identify components of the rationale guiding a given chapter. You may well notice a similarity of goals, instructional strategies, desired student activity, and evaluations among the ten descriptive chapters. In doing so, perhaps you will be able to develop your own exemplary rationale and program for teaching science to your students. I wish you the best of luck and am confident you will succeed.

Chapter 1: EXCELLENCE IN MIDDLE/JUNIOR HIGH SCHOOL SCIENCE

By

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Early adolescents, aged 10 to 14 years, in middle and junior high school have characteristics which set them apart from students in other grade levels. Physically and sexually they range from immature to mature; mentally their intellectual processes are in concrete, transitional, and early formal stages; socially they develop and change from a dependency upon their families for values and security to being dependent on their peers. The middle school and junior high years are a time for self-consciousness, re-evaluation of values and experimentation in wider circles of life. Students in this grade range go through drastic changes and adjustments. In so doing they secure basic skills for lifelong learning and formulate lasting attitudes and decisions. Planning and carrying out a program of science for this level must take their special needs and abilities into account.

This task force has identified characteristic features of exemplary middle and junior high science programs. The resulting criteria for excellence in science education at this level are reported here using the organizational format established by Project Synthesis as presented in **What Research Says to the Science Teacher, Volume 3.** Descriptions are in five categories; goals, curriculum, instruction, teachers, and evaluation. A concern for personal needs, societal issues, academic preparation, and career awareness is reflected in each category as well.

GOALS

Goals of an examplary science program contribute to the development of science literacy. Students should:

* Develop the use of skills in inquiry and problem-solving with particular attention to:

  Investigative and reasoning abilities;

  Gaining independence in following directions and in manipulating materials and apparatus safely and effectively;

  Practical applications of the scientific method;

  Learning how to learn.

* Gain an academic background which:

  Serves as an adequate foundation in science for students to function effectively as educated citizens whether or not they choose to pursue further formal science education;

  Provides a strong foundation in basic science principles for motivated and talented students to pursue further coursework in science or technology;

  Allows students to delay or reactivate career decisions related to fields of science or technology;

* Achieve attitudes which, when combined with logical reasoning, result in appropriate decision-making, particularly that involved in science and social issues;

* Experience science in interdisciplinary settings and in the world of work;

* Relate science education to an understanding of self, one's relation to the environment, and to role of science in one's daily activities.

Curriculum

An exemplary science curriculum emphasizes:

* Science processes with a major focus on inquiry;

* Topics in many science fields at a general level, with a balance among the life, physical and earth sciences;

* Practical applications and everyday experiences which are incorporated into the scheme;

* Areas of study including issues in science and society, career awareness, historical aspects of scientific thought, and the world community of scientists;

* The intersections of the cognitive, affective, and psychomotor domains;

* Topics, activities, and suggested instructional strategies which reflect a recognition of the predominance of students at the concrete and transitional levels of cognitive development in middle/junior high;

* A latitude for student input when making curriculum decisions and opportunity for pursuing independent interests;

* The interdisciplinary nature of science in a consideration of relationships between different fields of science as well as between science and other subject areas.

Instruction

There are numerous aspects of the teaching/learning component in the science program:

* A variety of instructional strategies are used;

* There is frequent use of concrete experience;

* Objectives take into account the variation in student backgrounds and cognitive levels and are designed for students to succeed;

* Technology and supplemental teaching aids such as textbooks, computers, and audio-visual materials assist in instruction;

* An optimal use is made of community resources, examples include field trip sites, outdoor eduction programs, independent study opportunities and interaction with men and women who can serve as role models;

* The needs for students' social growth, values clarification and progress toward self-sufficiency are addressed;

* Logical sequencing of planned experiences within units of instruction occur.

Teachers

The success of middle/junior high school science education depends on the teachers. In exemplary programs the teachers can be expected to have the following characteristics:

* They have a liberal arts education with a strong emphasis in science, the preparation in science representing a broad spectrum of science disciplines rather than being limited to a single field. Science teachers at this level are generalists rather than specialists. They have a strong grasp of science applications, roles for technology and career opportunities.

* They have specific preparation in the teaching of science and in the teaching of early adolescents.

* They continue to formally or informally update and upgrade their knowledge and skills in science, adolescent psychology, and instruction. They are well read and utilize their expertise.

* They can objectively carry out and profit from self-evaluation of professional skills.

* They have an understanding of pre- and post-early adolescent growth and of how middle/junior high level articulates in the k-adult spectrum in science education.

* They participate in decisions about curriculum, facilities and educational materials.

* They make optimal use of available classroom space, facilities, materials and apparatus, time, budget, and community resources.

* They improvise, adapt, and invent.

* They match appropriate instructional strategies and resources to student abilities, backgrounds, and interests.

* They relate genuinely to students and responsible individuals, are sensitive to moods and needs, and possess a sense of humor. They enjoy being middle/junior high school science teachers and recognize the importance of their profession.

Evaluation

The critical elements of evaluation in excellent science programs include:

* Program evaluation relates directly to the program goals. Evaluation of student performance relates to specific objectives in cognitive, affective and psychomotor domains of education.

* Individual differences in cognitive abilities, maturity and experiential background are taken into account.

* Evaluation of both process and product occurs in a variety of ways and addresses a multiplicity of program components.

* Administration, teachers, students, peers, and community participate in the evaluation process. The evaluators and those being evaluated understand each other.

* Evaluation of the program reflects an awareness of societal expectations for science education.

* Evaluation leads to improvements in quality, efficiency, effectiveness, and functioning of the program. It is constructive, ongoing, and consistent. It reflects awareness of local conditions, restrictions, limitations, possibilities, and potential.

CRITERIA REVIEW

The criteria for excellence in middle/junior high science should reflect current emphases in science education and new developments in effective instructional theory and practice. A periodic review of the criteria for excellence will help insure the criteria will match the current state of science education as well as to renew interest in efforts seeking to attain the "desired state."

Recommendations for reviewing and updating the criteria for excellence in middle/junior high school science programs include:

* The review is to be carried out every three years, during the second year of the M/JH Director's term;

* A committee of at least three will be appointed by the M/JH Director to re-affirm the appropriateness of the criteria and/or make recommendations for changes. The committee will include two members of the M/JH Advisory Committee and one teacher education and science curriculum specialist;

* Recommendations related to the criteria set are to be presented at the annual national convention meeting of M/JH Committee for purposes of discussion. Final re-affirmation or revision by the review committee should take constructive input into account;

* The Director submits a report of the review and an updated version of the criteria to the Executive Board.

Programs meeting these criteria should offer many opportunities for students whether they intend to continue in science or not. The goals, instructions, teachers, and emphases of these exemplary programs should measurably move students toward an enhanced scientific literacy and ability to do superior work in later science courses.

Chapter 2: SEVENTH GRADE LIFE SCIENCE

By

Sam S. Chattin

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Scottsburg, a community of approximately 5,000, located thirty miles north of Louisville, Kentucky, serves the needs of a basically rural population. Our school population reflects the homogeneity of this population. The Junior High School has an approximate enrollment of five-hundred students in grades seven and eight. The faculty numbers twenty-five with three instructors in the science department. We inherited a fully-furnished high school chemistry laboratory when a new high school was constructed in 1973.

Commencing in the Fall of 1975, our present principal successfully committed our administration to a program of "upgrading" our physical plant and its equipment. Today, Scottsburg is one of the best equipped general science programs in the State of Indiana. The department teaches a sequential course of study that carries through both the seventh and eighth grade years using the text, **Principles of Science**, book one and two, by Merrill.

Essentially our program differs from traditional general science programs in four basic areas:

* Animals help to teach almost every scientific concept. More than forty different species of animals, over 200 individuals, are housed in our classroom. They fall into three major categories: mammals, reptiles, and birds of prey.

* An over-riding focus on Man's responsibilty for the rest of the world and his role as a "custodian" exist.

* Most of the materials for our program are acquired by "recycling" within the total school program or from local sources.

* Complete student involvement occurs through their total responsibility for the care, maintenance, and training of these animials.

OUR PROGRAM

I must emphasize certain traditional characteristics of our program. I instruct six classes of seventh grade students each day. Each class contains between thirty and thirty-two students for a total student load of one-hundred and eighty to one-hundred and ninety students. We operate on a forty-five minute class period with five minutes between classes. As for funding of our program, the list of whom we do NOT receive funds from is endless. I quote these unexciting circumstances to lay-to-rest any suspicion that we do not function within the bounds and limitations imposed upon most public schools in this country.

I would also like to express my belief that pre-tests, tracking, behavorial objectives, and endless curriculum packages do not play nearly as important a role in the learning process of children as do the behaviors of their elders and peers and the opportunities in their environment. When close contact with elders, peers, and environment is disrupted, children still learn; they learn distrust, even terror, and acquire the ability to insulate themselves from their environment.

Children survive in schools by learning how to get by as unimportant individuals free of responsiblity for decisions, insulated from their own capacities, from each other, and from their environment. It is hardly surprizing that problems of support, control, racial hatred, and general apathy flourish.

I am also certain that the greatest part of the inertia which prevents positive change comes from the tendency of some teachers to teach in the manner they were taught. There are many examples of ecologically oriented curricla being taught within traditional school surroundings. The PROBLEM is that the message delivered by the texts contradicts what occurs on the school grounds, in the lunchroom, and often even in the use of the course materials themselves.

After eighteen years of teaching I now know that films on animals or field handbooks on summer-flowering plants do not turn-on the vast majority of our students to science. My very first experience with a live animal in a science class made me change eleven years of traditional science instruction. If a picture is worth a thousand words then the REAL thing is worth a thousand pictures.

We ARE the sum of our experiences. More devastating, we cannot become what we have not experienced. Because of this indisputable fact, we make every effort to have our students see, hear, smell, touch, and live with every species of animal native to our our locality. In a single school year this list might include raccoons, opposum, bats, ferrets, skunks, squirrels, rabbits, chipmunks, moles, shrew, many species of non-poisonous snakes, lizards, turtles, fish, hawks, and owls. They also came in contact with some species that are not native, either because they are endangered elsewhere in the world, or are interest promoting because of their uniqueness.

The students also have the opportunity to experience a resident Reticulated Python (4.3 m long), Burmese Pythons, Boa Constrictors, Caiman, Piranha, and poisonous snakes on loan from local herpetologists. Each

container or cage converts into a learning center by displaying information about its contents on the side of the cage. Displays of animal artifacts and books relating to the occupant of the cage are made accessible to the sudents. Topics range from care, feeding, behavior, reproduction, and nutrition to genetics, evolution, conservation, food chains, protective adaptation, social structures, animal first aid, disease, ecology, and death. The list of topics that can be interwoven is endless. Current controversies sometimes keep us involved for an entire year's discussions.

The major thrust of our work with animals revolves around rehabilitation. We have never encouraged anyone to capture and keep wild animals. We have always believed that laboratory experimentation with living materials, except in very isolated instances, can hardly ever be justified! By treating sick or injured wild animals, with the purpose of releasing them back into their native habitat, our students learn about their world better than any other way.

The response of individuals and groups that normally would align themselves against live animal activities in school situations has always been very positive with regards to our program. The State and Federal Governments have granted us permits to rehabilitate animals including those that are endangered. Our permits also allow us to use in our program those animals that cannot be returned to the wild.

Each year we receive countless numbers of injured, sick or unappreciated animals. Sometimes the demand overloads our capacities and capabilities. In these instances our students have sometimes had to make some tremendously heart-rending decisions. These decisions are not contrived, play-game decisions. When a student committee sits down to discuss the possibilities of euthanasia on a critically injured animal, realizing that they will be the ones to carry out the decision, the world becomes an awesome reality. This experience teaches a custodial responsibility. These are not mere simulations.

Students are trained as keepers to both care for and train those animals that are used on a permanent basis in our program. They are given total responsibility for these animals and, with guidance, make all the daily decisions concerning their care. Once again they acquire real knowledge, and eventually, understanding and appreciation. They also become resident experts concerning their particular charges. Later in each school year, they teach other classes by sharing their knowledge and experiences with those who have not had their opportunities.

What a pleasant metamorphosis when student go from rebelling against authority and the system to becoming part of it. Our greatest behavioral changes have come from students who had been classified as discipline problems. When invited to participate as a keeper, they become zealously protective of their charges and, as a consequence, project themselves into the authority role. What a pleasure it is for me and for them, for us, to work together in an activity that is important, needed, and many times critical.

We have found that the greatest possible learning comes about when the experience undertaken is labor-intensive for the participant. Therefore, students perform everything concerning the animals. Initially I serve as a resource. Eventually the total responsibility becomes theirs. The results are amazing!

Our students have lectured at hundreds of adult meetings as well as amongst their peers. We have had E.M.H. students lecture before national

audiences at N.S.T.A. and N.A.B.T. conventions. They spent hours teaching teachers how to care for animals. To me, this is the ultimate in education; to reverse the role of student to that of teacher.

At least weekly, and more often in the fall and spring, our animals, their habitats, behavior, food chains, effects upon the environment, mating, and young-rearing all become part of our regular classroom instruction. I place great emphasis upon the deflating of popular myths and superstitions which lead to misapprehensions and fears. Fears lead to extensive destruction of life and, on many occasions, to wanton cruelty.

Students also obtain an appreciation of their custodial responsibility as humans by recycling materials from the school and the community. The cages and containers are castoffs from the students themselves. Food for the basic rung on our "institutional food-chain," we raise over 3,000 rats and mice each year, comes from the leftovers in our school cafeteria. Woodshavings and newspaper for animal bedding comes from our industrial arts program and school library. Even the wastebaskets in our classroom offer up their bounty to be used as animal bedding and nesting material. The animals are recycled from the castoff, the injured, or the aged. All these materials are collected, sorted, and administered by student keepers. It has had an extremely soothing effect upon our administration and community that several thousand dollars worth of animals and equipment are acquired and maintained with few tax dollars being involved.

We also recycle local talent into our program. On a regular basis, veterinarians, biologists, conservationists, amateur collectors, and agronomists discuss current issues and events with our students. Local parks, playing fields, and vacant lots become places where field trips take place and where students may involve themselves in conservation projects. We are now planning the development of a three-acre outdoor laboratory in a vacant dump adjacent to the school. Everything for this project is being accomplished by recycling the land, material, talents, and skills of the community, school, and students.

HOW DOES OUR PROGRAM MEET THE CRITERIA FOR EXCELLENCE?

I believe that our program meets everyone of criteria established for Junior High Schools.

* Students make critical decisions. Evaluations results from the short and long-term effects of their decisions upon the well-being of their animal charges. The grades or rewards are not symbolic or contrived, but reflect the knowledge that they have bettered the existence of a fellow creature.

* Problems involving housing, feeding, temperature, light, behavior, and training of the animals must be solved by the students.

* Our students learn there is NO substitute for experience and the only true way to obtain experience is by actual involvement in the existence of other creatures.

* Aquired knowledge and the processes used have practical and immediate consequences. They also have long-range

consequences and offer insight into future decisions concerning further education, not necessarily college oriented, and eventual life-style.

* The program continually emphasizes the custodial nature of the students' existence upon this planet. From this students gain insight into intelligent decision making.

* The program presents the world as a whole, indivisible, and with eternally interrelated actions and consequences.

* We promote the development of attitudes involving extremely high levels of moral and ethical consideration.

* The program destroys the perception that education is a separate series of unrelated experiences by demonstrating the interdependence of all life and all decisions. This method enhances the learning for Junior High students.

* Students have a forum for examining and discussing societal issues.

* Positive role models exist through exposure to adults and peers who actually demonstrate doing something positive about their world.

* The program promotes student self-confidence by dispelling fear that results from ignorance and by providing opportunities for valuable, needed service.

* Students become sensitive to the resources available within their community and gain a new sense of value and pride in the community and its citizens.

* The program sensitizes the community to the positive nature of the school by involving them in many positive ways with teachers and students.

* Students become part of the evaluation process. Many times students acquire greater knowledge about a particular situation than even the instructor because of their proximity to their animal charges. They then can freely enter into the process of recommending change from a solid position of knowledge. Many of our methods of animal care and maintenance have come about through the recommendation of our students.

* The program allows the student to be equal to his intructor on at least some body of knowledge. When a student realizes he can teach you something, the barrier of the traditional teacher-student role no longer exists.

STRENGTHS AND WEAKNESSES

Our major areas of strength include:

* The incredible enthusiasm of the students for the animals and their overwhelming desire for involvement with living things. I honestly have come to believe that any teacher could teach any subject by using living things and see an immediate and measurable increase in the performance of their students.

* Because of the recycling nature of the program there are almost no costs involved.

* Most instructors will acquire their basic body of knowledge in the same way their students will eventually have to acquire it, through experience.

Three areas of difficulty involve:

* It takes a rather lengthy period of time, two to four years, to correctly build the depth of program that we have undertaken.

* Everyone concerned with the program must learn to deal with the real world rather than selected parts. I call this "dealing with the puppy syndrome." Everybody loves a puppy until he excretes, gets sick, makes noise, brings home fleas, or grows into adulthood. Hawks and owls that excrete on the floor of your classroom or desembowel squirrels in front of your class are sometimes difficult for some to appreciate. Pythons that swallow "cute-little- bunnies" are also difficult for some to appreciate. The list goes on. We have found this especially true in a day and age when most of us don't even know where our wastes will eventually wind up and have never personally killed the animal whose flesh we eat.

* You must adjust to the fact that in the rehabilitation of injured and sick animals most of your experiences will end in what the unknowledgeable will perceive as failure. The statistics demonstrate that you will save precious few animals and fewer still that can ever be successfully released. Most will die. Some you will have to kill. These experiences can be a tremendous learning device for our students. Life is fragile and delicate, much more than any of us realize.

OUR BEGINNINGS

In 1974, a very dramatic change occurred in my teaching career. I was transferred from my position at the Senior High School to my present position at our Junior High School. I was ill-prepared for the difference that I found in the make-up of the seventh grade student compared with high school seniors. I had always thought that Junior High students were just smaller. I had always been a stand-up lecturer and loved to perform before my captive audiences. My first two weeks with Junior High School students resulted in my sincere contemplation of resigning my teaching position and volunteering for the next marine corps beach assault. My best jokes went

unlaughed at. There were no visible signs that my students comprehended anything I presented to them. And their faces expressed nothing but severe, terminal, BOREDOM. I immediately acquired the most superior inferiority complex in the system.

After my wife, a teacher in our elementary school, had steadied my reeling ego and bandaged my self-esteem I climbed back into the saddle, set my teeth, and began to experiment. A la Paul Ehrlich, many, many, many, MANY trials later, quite by accident, I came across my first live animal in a workshop at an N.S.T.A. convention held in Indianapolis. An elementary teacher from Chicago pulled out a 4 meter Boa Constrictor that he was using in his classroom and EVERYONE went bonkers! The seed was planted. Odd, that I had undergone eighteen years of organized schooling and then taught for eleven years and had never come face to face with what I was teaching students to understand and appreciate. That was the most fortuitous moment of my teaching career, and I have never been the same.

Upon returning to Scottsburg I discussed the prospects of purchasing a snake with my principal. After thirty minutes of telling me that, "It would be unwise and dangerous; they are all poisonous aren't they?" he finally said, "If you bring one in here, I want your resignation on my desk the same day!" Well, with that kind of encouragement, what else could I do?

The next morning I took the issue to my students. They went beserk. By the following day they had donated $86.57 in pennies, nickels, dimes, and quarters. That weekend we purchased the school's first-ever resident reptile. An overwhelming response occurred. Never had I seen such interest. Never had I seen such enthusiasm. Never had I seen such anger in a principal!

My principal's negative attitude and constant non-support turned out to be the second greatest blessing I could ever have had. He asked me for my resignation; I was not able to find a suitable one. However, his anger did force me to make the program totally independent of school funding. So began our "recycling" effort. We had to scrounge for everything! We became sensitized to cast-offs, waste, and garbage; we needed them!

Following our initial purchase we began to receive gifts of guinea pigs, hamsters, gerbils, canaries, and other animals that people no longer wanted as pets. Then one afternoon a motorist, who had a daughter in one of my classes, showed up at the door with a Great Horned Owl he had just hit on the highway. Our rehabilitation program was born!

From that moment until now there have been literally hundreds of people who have shared their knowledge, time, material goods, and love for animals with our students. Teachers, Zoos, Conservationists, Wildlife Organizations, civic and religious groups, Scouts, Doctors, Veterinarians, but mostly our students, have encouraged, maintained, and supported our program.

We have now evolved into a program with thousands of dollars worth of equipment, material, and animals, some of which could not be purchased at any price, because they are protected by Federal law. And it has cost our school system almost nothing. It also stands as a constant expression of our concern for our world and its resources.

FACTORS CONTRIBUTING TO OUR SUCCESS

The major factor in the success of our program involves student interaction with the animals. Even while laboring through the most tedious sections of material the animals offer relief for the students and the instructor. Levers and the principles of their operation become more teachable using the wing of a living Red-tailed hawk as a model. Medelian genetics becomes real when expressed in the coats of 300 mice.

The second most important factor includes the participation of the students in the maintenance of the animals. I do not have the time to feed, clean, and train the creatures we possess. Without the involvement of our students the program would have to be scaled down considerably or abandoned completely.

Recycling covers most of the cost and maintenance of the program. The only real costs is that of the energy and time expended by our students. And, I also know that the rehabilitative nature of our activities makes our program palatable to all concerned.

SUCCESSFUL TRANSPORTATION TO OTHER COMMUNITIES

I was most ecstatic when Greg Smith, of Crothersville Senior High School Science Department, asked us to help implement a similar program in his school system. Their two year old program flourishes with all the results we had predicted. We have set up a small consortium between the two schools and consult on the purchase of certain animals to avoid duplication. Periodically we trade different species between the two institutions.

I have had numerous contacts in the last two years from other schools wanting to use our program as a model. Most of this interest was generated by workshops I presented at the Hoosier Association of Science Teachers convention, the National Association of Biology Teachers convention, and the National Science Teachers Association convention. Based on discussions with these individuals who attended these sessions, their versions of our program are doing splendidly.

I have presented this program in seven differnt states now and have always met with enthusiasm and interest on the part of administrators, teachers, and STUDENTS. Many of these systems expressed interest in initiating programs similar to ours.

I have no doubt that what we do can be adapted to any community, school system, or grade level, because of the unbounded flexibility of the program.

EVALUATION DATA

Until this year, I have only been able to evaluate in light of the personal testimonies of my students, parents, and the reactions of those who have been exposed to the program.

A disproportionately high number of our students have shown interest in science teaching, veterinary science, conservation, and animal related careers. Several students have interned at a zoo, and innumerable students have become involved in wildlife rehabilitation.

This year I spoke with Dr. Edward L. Vockell of Purdue University, Calumet, about a program he pioneered which can measure changes in humane

attitudes. Until Dr. Vockell and his associate, Frank Hodal, Executive Director of Humane Environmental Education Development, Inc., in Gary, Indiana, developed the "Fireman Tests" in 1978, no test had the capacity to measure humane attitudes. I became aware of their efforts through an article published in the **Hoosier Science Teacher**, Vol. VIII, No. 2, December 1982.

We are only the third school district in the United States to participate in the administration of this testing device. From the results of these tests we will be able, for the first time, to quantitatively measure the results of our program, at least in terms of attitudinal changes.

As Dr. Vockell is quick to point out in one of his articles, until recently, only non-teachers have been involved in humane education. In studies conducted in Hammond, Indiana, and Jefferson County, Colorado, significant changes were produced by a **master teacher.** This implies that until **teachers** actively engage themselves in well-planned strategies to induce change in student's attitudes there will not be changes. The inspiration, growth, and development of our program is good evidence for this.

Chapter 3: THE ROCHESTER SCIENCE PROGRAM

By

Marvin Mikesh, David Arlander, Sam Bailey, George Lueder, Howard Monnet, and Roger Nelson

John Adams Junior High
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Rochester, a city of 60,000, combines the friendliness of a small city with the culture of a large city. World famous as a medical center, Rochester has more recently become a rapidly developing industrial and high technological community led by such firms as I.B.M., Waters Instruments, and Telex Communications.

To satisfy the cultural needs of its citizens and visitors, Rochester supports a municipal band and symphony orchestra. We also enjoy a diversified art center, medical and historical museums, summer open-air concerts, performances by visiting musical artists, name bands, and traveling show troupes.

No matter what one's preference for recreation might be, it is likely to be found in Rochester. In addition to excellence in all sports, Rochester boasts bowling at four centers, swimming in several large outdoor and indoor pools, and ice skating both in winter and summer. Tennis, archery, hunting in all seasons, close-by camping, and water sports are also available.

The following paragraph, taken from a Chamber of Commerce publication, illustrates the community's commitment to education.

> Rochester's school system reflects a desire on the part of its citizens for the finest in educational facilities and personnel. The quality, pioneering, and exceptional results of the community's educational institutions have attracted nationwide attention. A two-year college, adult evening college, schools of nursing and other professions, and classes for both handicapped and exceptional students supplement the regular public and parochial elementary and high schools. A well-equipped and much-used public library is another Rochester asset.

GOALS

Basic to the establishment and existence of any science program is the conception of a philosophy relevant to that program. Once the philosophy is conceived, teaching and management objectives consistent with that philosophy can be established and changed when it seems appropriate. Science at John Adams Junior High School stresses the following components:

* It is oriented toward laboratory-centered experiences.
* It provides experiences that create excitement about learning science.
* It allows each student the opportunity for some form of daily success.
* It allows students to learn at different rates and in various ways.
* It allows students freedom to work with other students with whom they feel comfortable.
* It allows, through laboratory activities and a variety of instructional techniques, a self-directed student to develop the ability to reason analytically and to think critically.
* It allows for the optimum usage of the individual talents of the teaching staff through team planning and team teaching.
* It seeks to generate greater student interest in science so that the student will pursue additional classes in science at the high school level.

TEACHERS

The John Adams Science Department has an extremely well-trained staff. The average number of years of college training is 5.7. Each staff member has received at least one National Science Foundation Grant to further his/her education.

The quality of instruction in any department is reflected by the attitude the teachers have regarding their profession and the school in which they teach. John Adams originally was staffed by teachers who chose to design the program. Since that time, all members of our department have had the option to teach at other grade levels and at other schools but have chosen to teach at John Adams. They are proud of their school, the student body, and the quality of work they are performing. This is reflected in the positive learning atmosphere that pervades the classroom, the lack of discipline problems, and the general attitude of the student body.

The members of the science department have been divided into teaching teams. Each team shares a common office area which provides an excellent opportunity for team planning, continuous evaluation of teaching

techniques, the development of written materials, and the building of physical teaching apparatus. Each team plans and sets up every lesson cooperatively. During team planning, techniques of presentation are discussed, and, after delivery, evaluation of the lesson occurs. A constant dialogue exists between the team members that enables the effectiveness of teaching, creativity, and professionalism to increase.

One member of our department has been granted leave this fall to work on the I.B.M. School Computer Project, a pilot program established by I.B.M. and School District #535. Upon completion of the sabbatical leave, he will return to John Adams and help establish the use of microcomputers as an instrument to enhance classroom instruction.

The Rochester School District has a science consultant to serve as a coordinator of science curricula, instruction, and budgets. At John Adams, we have our own budgets for supplies, capital outlay, textbooks, and repair and replacement. Each spring, general equipment needs are determined by each teaching team. After review by the department chair, these go out for bids.

The members of our department have considerable input into the decisions that are made regarding instruction at John Adams. The department chairperson relays ideas presented at team and departmental meetings to the science consultant and the John Adams faculty council on a regular basis. We, as teachers, feel we are professionals and capable of making decisions that promote good education. The excellent administrative support and the opportunity to be involved draws out the best in each staff member.

INSTRUCTION

Science instruction at John Adams is based on the premise that students will learn best if they are presented with a variety of learning experiences. Class-time is divided into the following components:

* Approximately one-third of the student's time is in lab.

* One-third involves teacher presentations, demonstrations, lectures, and the use of visual materials.

* One-third is spent in class discussion, problem solving, and testing.

At all grade levels, team members have developed learning packets. Each packet states learning objectives, class activities, and self-tests. Packets are designed so that students and teachers can have continual feedback as to progress and depth of understanding. This approach enables teachers to monitor student progress, diagnose weak areas, and prescribe appropriate help.

The members of the department, in planning their daily lessons, employ several procedures to insure lesson continuity and full coverage of the topic being discussed.

Each team maintains a complete set of daily lesson plans for the full course of study. These are kept in a central file with ready access by all members. These plans are amended continuously to keep the material relevant.

Each lesson incorporates Madeline Hunter's seven parts to good lesson design:

* Anticipatory set to gather students' attention;
* Statement of objectives for the day's lesson;
* Input from teacher (presentation of subject matter);
* Modeling -- examples, illustrations, etc.;
* Check for understanding;
* Guided practice;
* Independent practice.

Accelerated Science Program

Approximately 20 percent of our student body participate in the Accelerated Science Program. This program, designed for science students who are talented and/or highly motivated, provides an intensified science program and offers additional classroom challenges and in-depth studies. Selection to this program depends on elementary teachers, parents, school counselors, and the student. Evaluation of attitudes and performance occurs several times during their junior high years.

Additional Learning Centers and Programs

When John Adams opened in 1970, health instruction became part of the science department allowing for more laboratory investigation in health classes and preventing duplication of instruction. Health, biology, and life science share a common office enabling the staff to compare lesson plans and share ideas.

Our department has access to a district planetarium and nature center. The planetarium seats 75 students, is fully equipped and is staffed by a former traveling science teacher for the National Science Foundation.

The school district also staffs and maintains a nature center. Quarry Hill, a 212-acre park, includes caves, a quarry, creek, forest, fresh-water pond, and a 4,000 square foot nature center to aid in field instruction in the natural sciences. Our students use this facilty throughout their elementary and secondary science studies.

Students at John Adams participate in science fair competition strictly on a voluntary basis. Student numbers are not large; however, the quality of work is excellent. We have had winners at all levels of competition and are especially proud that a ninth grade student of ours qualified for the International Science Fair in 1981 and earned a fourth place award in physics.

During the summer months, two educational opportunities exist for the students of our school. Both programs provide students with a chance to apply the knowledge learned during the regular school year to real life situations.

* As an extension of the earth science class, students can elect to participate in an 800-mile geology camping trip to northern Minnesota.

* A field biology class, which emphasizes research and data collection, is offered at the Quarry Hill Nature Center.

Inquiry Lab Approach

Students spend approximately one-third of their time in lab activities. The majority of the labs are teacher designed for the purpose of providing experiences to supplement the topic being discussed. Where appropriate, inquiry labs are introduced to promote application of the principles and individual thinking. A few examples of inquiry labs are: In "Natural Selection," students hypothesize the influence of color in the natural selection process. Students test the hypothesis by observing different colored "paper worms" in various outdoor settings and must apply their results by giving examples of the natural selection process in the plant and animal kingdoms. In "Weather Forecasting," students collect daily weather data using the school weather station and forecast the weather by using U.S. Weather Bureau maps. In "Decision Making," stduents presented with a specific situation relating a health decision (i.e. to drink or not) must follow a decision making model and arrive at their own decision. In "Diet and Kidney Function," students follow specific diets and collect personal urine samples. Various tests determine the effect of the diet on the functioning of the kidneys. In "Heat Transfer," students bring an ice cube to class in a homemade container. They must design and build a container that slows heat transfer. In "Electric Motors," students construct an electric motor that works. They research various designs and incorporate any design they choose. Unique designs, as well as rpm/amperage data for each motor, are displayed.

Our school district has purchased the Phillips Oil "Search for Solutions" series of films. We use these films to highlight both inquiry and career education.

Daily Life Application

A major goal of each teaching team is to help students understand how scientific principles enter into their every day experience. During lectures and classroom discusions, our teachers continually illustrate and expand each lesson by using examples of science application in daily life. The following examples from the 9th grade team illustrates how this goal is being implemented.

* The study of density and specific gravity allows students an opportunity to determine the freezing temperatures of different solutions of antifreeze using hydrometers similar to those used by service stations to check auto radiators.

* The concept of horsepower becomes easier to understand when students determine their own horsepower by running through a measured course. In addition, each student has a chance to compete in the horsepower derby where winners get their names engraved on a plaque on a permanent display in the science area.

* Ultra sound pictures of an unborn fetus and a kidney filled with stones help to illustrate the importance of sound energy in a large medical center such as Rochester. The echo of sound can also help find the famed Minnesota Walleye as we look at the operation of a fish locator.

* Seeing their own speech patterns or favorite rock music on an oscilloscope screen helps students understand how the brain can recognize speech patterns of friends who call on the phone.

* Aerial thermograms of the city of Rochester enable students to find their own homes and look for heat loss on pictures produced by infrared energy.

* Keeping a current events notebook of newspaper clippings encourages students to look for news on scientific developments at local, state, national, and international levels; additionally, it fosters a desire to continue individual learning.

CURRICULUM

The science curriculum followed by Independent School District 535 was developed and written by science teachers from within the district, including all the members of the John Adams Science Department.

Individual schools modify the curricular topics according to the needs of their students and the particular talents and strengths of their science staff. The John Adams Science staff has excelled in presenting a strong science program for their students. The general topics covered in grades 7, 8, and 9 of the K-12 Science Curriculum include:

Seventh Grade Life Science (one semester)

I. Metrics including basic units and measurements.
II. Observation of plants and animal cells using the microscope.
III. Plants.
IV. Invertebrates and vertebrates.
V. Functional systems of the human body.
VI. Biomes and food webs.
VII. Community interactions including succession, cyles on nature and behavior.

Seventh Grade Accelerated Science (one semester)

I. Introduction to science.
II. Geology including earth structure; minerals; volcanism and igneous rocks; weathering, erosion, and sedimentary rocks; diastrophism; and continental drift and plate tectonics.
III. Meteorology including struction of the atmosphere; heat transfer; humidity, precipitation, and clouds; atmospheric pressure, winds, and circulation; air masses and frontal systems; storms; and weather prediction.
IV. Astronomy including tools of the astronomer, stars and stellar evolution, galaxies and nebulae, principles of orbiting bodies, and the solar system.

Eighth Grade Health (one semester)

I. The interpersonal relations unit focuses on self-image and self-esteem; behavior, attitudes and values; decision-making skills; and emotional ills.
II. Sexuality unit covers family life, adolescence, dating, and veneral disease.
III. A unit on chemical substances discusses body modifiers, tobacco, alcohol, and other drugs.
IV. The human machine unit discusses health status, circulation and heart disease, cancer, and theory of exercise.
V. Safety and first aid.
VI. Consumer health including advertising health aids, fadisms, nutritional cure-alls, and quackery.

Eighth Grade Science (one semester)

Topics covered include those in the seventh grade accelarated program.

Eighth Grade Accelerated Science (two semesters)

Topics include those in regular ninth grade physical science class; however, the topics are covered in greater depth.

Ninth Grade Physical Science (two semesters)

I. Methods of measurement in science.
II. Natural forces.
III. Mechanical energy.
IV. Heat energy.
V. Wave energy.
VI. Electrical energy including consumer electricity.
VII. Current topics on energy and use of natural resources including energy alternativesand resource management.
VIII. Nuclear energy and nuclear electrical power.
IX. Chemical energy.

Biology (two semesters)

I. Introduction to biology.
II. Chemistry of life.
III. Cell and cell physiology.
IV. Bio-energetics.
V. Cell reproduction and growth.
VI. Genetics and human genetics.
VII. Evolution and taxonomy.
VIII. Protists.
IX. Plant kingdom.
X. Animal kingdom.
XI. Human biology.
XII. Ecological interrelationships.

EVALUATION

Staff Evaluation

Our entire school district participates in an on-going staff development program. In-service training in Clinical Instruction has been, and continues to be, provided by trained staff members. Two members of our science department participated in the pilot program before it was officially adopted by the district.

Clinical Instruction trains the staff in Madeline Hunter's principles of "Clinical Teaching." Madeline Hunter's seven parts to a good lesson design, as well as teaching for transfer, reinforcement, and motivation have become a part of our daily lesson plan. These principles have contributed more to our professional growth and development than any other methodology.

Evaluation of each staff member by one of the building administrators occurs every two years as part of the clinical instruction program. The evaluation builds on the strengths of each individual staff member and helps to improve his/her use of the principles of "Clinical Teaching."

Self-Evaluation

Because of the team planning methods, all staff members engage in continuous evaluation and revision of lessons. The written materials that students receive are generally in the form of "packets" which are revised and modified each year. The use of packets as a method of presenting lessons and assignments has been in use since the opening of John Adams in 1970. It has proven to be a convenient and effective learning device for the students.

Our science staff has been together, virtually unchanged, since the building opened. The degree of compatibility and cooperation shown between staff members on a day-to-day basis remains extremely high. This feeling of mutual trust and respect that exists between our staff members has probably been the key to our ability to work as a team in an effort to continually improve our performance as teachers.

Student Evaluation

Our department agrees that the evaluation of a student not only determines the success of a unit but also should determine the design of the next unit. Realizing that students learn at different rates and through various modes of instruction, we try to design a course of instruction that will offer as many avenues for success as possible. Students respond differently to various types of evaluation depending upon their personality, background, social postion, self-confidence, etc. With these differences in mind, we attempt to include as many types of evaluation as possible in order to measure the student in ways he/she feels most comfortable and least threatened.

The district's curriculum guide which all of us have helped to develop through summer curriculum workshops determines our basic teaching objectives. From these basic objectives, each teaching team has developed a set of specific objectives that specify the most important aspects of each particular unit. Each packet contains these specific objectives under the headings "Student Expectations," "Student Requirements," or "You Should Be Able To"; titles vary by team.

The objectives include written "Self Tests" and answers. Students use these to check their understanding as they progress through each packet and prepare for the graded exam. These self-tests are not graded and, therefore, are non-threatening to students.

Teachers regularly evaluate the students' progress as they work through their packets. This "Checking for Understanding" is acomplished in the following ways:

* Oral quizzes at the beginning of a class over the previous day's lesson help determine if the class is ready for a new topic or if review is necessary.

* Simple hand signals, thumbs up or thumbs down, are used as quick non-threatening ways to check the understanding of a single concept as class is progressing.

* Meeting individually with each student, teachers use checkpoints (question-answer sessions) to see if the student understands the concept.

* Occasional individual student conferences give us the opportunity to assess the student's progress as well as to give counsel and direction.

* Bi-yearly Parent-Teacher Conferences involve the parent in the evaluation as well as to reinforce the learning process.

Short unit tests, 45 points or less, given after completion of the packets make use of objective, subjective, and lab practical items. The specific objectives stated in the packets determine the test questions. Several teaching teams have a "bank" of questions for each objective and can easily vary exams from year to year. This also gives the teacher the ability to provide different questions for a make-up test or a retake test for a student who has performed poorly and desires a "second chance." An

electronic test scoring system has been implemented to weight test questions against objectives to determine if we have, indeed, met our objectives. Parent volunteers are available to help students with reading disabilities who prefer to have their tests read to them.

Students are graded quarterly with approximately one-third determined by packet and lab activities and two-thirds by test results. Mid-quarter achievement is also assessed and notices are mailed to parents.

North Central Evaluation

Our school was the third junior high in Minnesota to participate in the North Central Association evaluation. The task of going through this comprehensive evaluation was not an administrative decision but a desire on the part of the staff to take a critical look at our program. Currently, we are in the process of applying for another North Central evaluation. Formal evaluation will take place during the 1983-84 school year. We are all confident that our program is getting better each year and will continue to do so.

Chapter 4: LABORATORY AT THE ZOO

By

Kathaleen Burke, Anne Michael, and John Gallivan

Buffalo Science Magnet School
Buffalo Zoological Gardens
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Buffalo, the second largest city in New York State, covers an area of approximately 43 square miles with a population of just under 400,000. Neighborhoods with strong ethnic concentrations remain as several areas of the city are not easily accessible by transportation routes. As a result, the attitudes of city residents reflect a long-standing and extremely emotional bias in favor of neighborhood schools.

Buffalo's growth pattern has been similar to that of many large cities. After 1950 the city began to experience a steady population decline, due in large part to the familiar pattern of suburban migration and a severe decline in industry. These factors contributed to a gradual lowering of the school population, with a disproportionate decline in the majority to minority ratio. The current enrollment ratio is approximately 52% minority students with a concomitant increase in the number of students from families at lower economic and educational levels.

The Buffalo Public School system, the largest single school district in New York State, is the site of an extremely successful, court-ordered desegregation plan. Initiated in the 1976-77 school year, the plan may be the most successful in the country. In fact, neighborhood school biases have been overturned and school population decline is now at a rate lower than any of the surrounding and metropolitan suburbs! Buffalo's system-wide program of magnet schools, early childhood centers, and academies provide an educationally excellent curricula and have brought about this success.

The City of Buffalo, under court order to desegregate its schools, created choices for students so the process would come about voluntarily. Part of the plan involves a network of magnet schools with their own unique program designed to attract students with special interests.

The Science Magnet purpose, and the fundamental objective of the Zoo School Component, is to draw city students to an alternative educational environment which stimulates and encourages learning by using the scientific process approach.

One of the magnet schools, School 59, a Science Magnet, provides a unique K-8 program using three distinct sites: a home-base school, the Buffalo Museum of Science, and the Buffalo Zoological Gardens. The Zoo Component of the Science Magnet is the subject of this chapter.

This junior high school component, planned and implemented by the Buffalo School District and the Zoological Society, allows students to learn from the Zoo's veterinarian, curators, and horticulturalist that the zoo's collection is not just "for fun." Planning for animal care, breeding, and aesthetic presentation is very serious and careful business.

This two-year program developed in zoogeography and syncology combines a knowledge of plants and animals to study the development and survival methods of all living things, including man.

The zoo provides raw material for student research, study, and work projects. Whether these projects touch on genetic management, planting and propogation, off-exhibit research, ecology, medical care, the business of running a leisure facility, or associated careers, a wealth of facts and figures is available.

The scientific process permeates every area of study while consistent reinforcement of disciplined critical thinking occurs in daily classroom activities. These activities include writing, microcomputer programming, weekly scientific investigations, and student self-evaluation techniques. Increasing independence and student responsibility are carefully built throughout the program. Above all, the application of science to everyday life is continually stressed.

The Zoo Component of Buffalo's Science Magnet presently serves an integrated group of 107 students in the seventh and eighth grades. Standardizd tests in reading, writing, and mathematics indicate a student population of widely varying skills.

The scientific method, viewed as a critical process applicable to all disciplines and a necessary, lifelong skill, provides the unifying strand throughout the program of the Zoo Component. Along with the traditional academic subject areas, time is spent defining and practicing specific aspects of scientific and inquiry processes. Even communications to parents reinforce the basic components of the scientific method! But, more significantly, students constantly approach both process and separate subjects from the interdisciplinary perspective of broad societal issues or from the perspective of a cross-disciplinary, extended investigation.

Confines of the classroom disappear as students make extensive and regular use of resources and personnel at the Buffalo Zoo and, to a lesser extent, of community resources throughout Western New York. This unique sharing of a public city cultural resource with a public city school provides a mechanism for the distinctly non-traditional, hands-on approach of the Zoo Component.

Active student involvement occurs in planning, decision-making, implementation, and evaluation. Grouping provides a flexible instructional tool rather than a track. Some groups may be based on ability, but just as frequently groups are based on common interests or shared problems to be solved. Interaction with adults occurs on many levels, from apprenticeships, to colleagues, to role models. Rapid growth of students'

behavioral maturity and the development of mutual respect on the parts of student, resource person, and teacher often results.

Byproduct learning has been observed even sooner than expected. Students have demonstrated an understanding of "civic responsibility" and "public ownership" well beyond that normally found in junior high classes. Acceptance of peer evaluations is good-natured and positive, with questions, criticisms, and suggestions now being shared as a matter of course. Students view science as an integral part of life, both in particular careers and in their everyday interactions with the environment.

OUR PROGRAM

This program's approach to content treats the scientific process as the underlying framework for all disciplines. Thus, the scientific method becomes both the primary tool and the primary goal of the Science Magnet curriculum. Student understanding of the scientific approach will not only serve their needs throughout formal education, but will also extend itself to frequent use during their adult decision-making. This aspect becomes more and more important as the technological level of society grows at an exponential rate.

We want students to:

* Focus on the scientific process as a framework for all learning;

* Develop the ability to use critical thinking and research methods as practical problem-solving skills;

* Develop an awareness of science as an integral part of everyday life and an underlying discipline;

* Experience a practical, hands-on, non-traditional program of which combines the learning resources of the school system with those of a working zoo;

* Explore science as a life skill and as a unifying interest through which to promote personal and career development;

* Have an attitude of scientific regard and perspective which can foster personal growth, individual achievement, and greater social responsibility.

Financial costs have been borne primarily by the District with some relatively small amounts of Federal and State Desegregation/Magnet monies being used to supplement the program. The Buffalo Zoo and the Buffalo Museum of Science have been major contributors of space, personnel, and resources. Their boards and their staff have been invaluable in terms of providing cooperation and support.

Use of scientific processes serves some of the children well because they will go on to higher education beyond high school, but many others will have little exposure to formal science training after ninth grade and will use these processes in everyday life. Perhaps the fact that they will be skillful, critical thinkers, comfortable with science and with its

impact on their lives, is one of the more important outcomes of the program.

Using the Buffalo Zoo as a laboratory, students carry out scientific processes of information gathering, classifying, recordkeeping, inferential thinking, analysis and interpretation of data, drawing conclusions, and formulating new ideas. All of these activities evolve naturally from concrete, practical considerations of daily zoo maintenance, research, and development.

The teacher-student relationship approaches a craftsman-apprentice relationship with a strong emphasis on conferencing throughout the program. This technique is particularly well-suited to the zoo setting since activities can be designed to meet many ability levels or interest areas. For example, a recent activity involved sharing data following a period of observation in the reptile house. In one group, although students had individually made animal observations and had recorded data on teacher-designed record sheets, **teachers directed** the sharing, classification, analysis, and interpretation of that data. But in another group, **students** conducted the assigned tasks on an individual or small group basis, with teacher involvement limited to goal setting. This group compared, discussed, and evaluated data independently. Their final conclusions separated behavior observations into direct and inferential, and their proposed suggestion for improving future data gathering was to develop operational definitions to use in observations. Conferencing occurred at several levels in this activity, from actual zoo work to classroom follow-up, again depending on the student ability level.

The Zoo also provides students with similar interests the opportunities to work together regardless of ability levels. An apprentice plan allows students to work with the horticulturist on science fair projects, career appreciation studies, and development of home gardens. The veterinarian has worked with students on science fair projects. Most recently he assisted an average female student in her work on a science fair project entitled "Can RBC and WBC Morphology Be Used to Identify Species." The curator of birds had an apprentice working on an Andean Condor behavior study, an effort to compare the behavior of captive versus wild members of the species. Grouping students by centers of interest has also been successful at the State University of New York/College at Buffalo Research Library, at the Buffalo Museum of Science, and at our overnight outdoor education activities at Whispering Pines Camp.

In addition to working with apprentices and students doing research, resource persons at the Zoo perform a variety of class presentations. Beyond the horticulturist, veterinarian, and curators, many others are used as role models and resources. These people include keepers, education staff members, zoo volunteers, publicity and development staff, and maintenance staff.

The program emphasizes the development of communication skills. Again, the Zoo serves as a laboratory for student work. The end-of-the-year activities for both seventh and eighth grade curricula involve lectures, dramatic presentations, and lecture-demonstrations at the Zoo for the general public. Last year, students wrote and produced a puppet show about Buffalo Zoo history. **Four thousand** pre-school students viewed the show! Another group of thirteen students researched, wrote, rehearsed, and presented lectures on selected animal exhibits. These lectures were presented up to 75 times by each student during the allotted days at the

Zoo in May and June. This is no ordinary student presentation. In order to facilitate public viewing of the lectures, 16 students organized a tour route and were trained in how to conduct visitors on a tour from one lecture site to another. People touring ranged from classes to families with preschool children to senior citizens. Group size ranged from two to approximately thirty people.

This year, the eighth graders intend to extend lectures into lecture demonstrations. One student will lecture on animal anatomy, adaptations, and ethology while another will demonstrate, using grids and frequency tables to record operationally defined behavior, an actual ongoing behavior study of the animal.

Peer evaluation occurs frequently in preparation for all these presentations. Students volunteer to critique each other, conference jointly with a teacher, and return to their site for further practice until they judge their product ready for the public. At that time, they invite the teacher to play the role of the public.

The pride and ownership that students have developed about their presentations and service to the public extends to other areas. An unanticipated but welcome spin-off of the program activities includes the respect with which they treat the Zoo and the efforts they make to remind others to comply with such rules as "no littering" or "don't feed the animals." Students are also aware that the extreme and wholehearted cooperation of Zoo staff results, in large part, in a positive impact of pupil behavior. We feel this civic responsibility towards a public facility extends beyond the Zoo to other community resources used for field trips and field based assignments.

A major activity at the Science Magnet includes seventh and eighth grade students doing individual, experimental projects and showing them at a school-wide science fair. They may choose an exhibit-presentation, but they are encouraged to use the lecture-demonstration format. Preparation begins at the beginning of the year with classroom experimentation and demonstration. A gradual progression through the scientific process occurs until the student assumes full responsibility for working through the necessary steps to reach a solution. At the eighth grade level, students build upon, refine, and advance their seventh grade skills. Students work at refining library research skills and recognizing variables as either manipulative, responding, or control.

Eventually, students select a general problem area. Then they select a specific problem area, and, ultimately, the operational problem becomes clear. This selection process occurs through conferencing, student revision, and final agreement between student and teacher. The next step, developing the hypothesis, occurs through group discussion, writing assignments, and background reading. Eighth graders are expected to do more background reading than seventh graders.

The absence of an on-site library and the relative scarcity of classroom resource texts limits this phase. The problem has been remedied magnificently since the Zoo component moved from its temporary facilities to a permanent base in the Children's Resource Center on Zoo the grounds. Currently students use the local college library as often as possible.

At this stage, students continuously inform the teacher of their progress through written reports while teachers use conferencing to guide student progress. Finally, experimental results are submitted and preparation of the presentation begins. Extensive peer evaluation occurs for both exhibits and lecture-demonstrations.

Experts selected from the local community and school system personnel judge all entries using criteria designed to evaluate use of the scientific method and quality of presentation. Students are rewarded in a school-wide assembly, with the top six winners going on to compete in the Western New York Science Congress.

These activities help students refine their critical thinking, research skills, and use of the scientific method. What starts in early primary grades with very limited, concrete instances of observing and reporting now expands to its full configuration including experimental design, analysis of results, and communication of findings.

SOME RELATED COURSES

A locally developed course which relates life sciences to man, to ecology, and to environmental studies provides an additional major thrust for these grades. In grade seven, Zoogeography links earth science to animal classification and distribution. In grade eight, Syncology uses zoogeography as a jumping-off point and then goes on to synthesize the inter-reactions of many factors which operate in an environment. These courses emphasize human structure, function, and place in the environment with the Zoo used as a laboratory to make observations from which to draw relevant conclusions.

An additional specific curriculum area being carefully developed and expanded is the computers studies program. This program seeks to develop computer literacy in the entire seventh and eighth grade population. At the same time more able mathematics students are encouraged to develop proficiency in BASIC using a microcomputer in the solution of assorted model problems. By developing a BASIC vocabulary and using programming skills in response to real world problems students focus on the computer as another problem-solving tool.

In addition to writing their own programs to solve problems, students also edit library programs, making them applicable to their particular needs. This exercise exposes students to well-written programs, forces them to consider the exact position and appropriate nature of their editing, and assists them in concretely grasping the impact of various BASIC statements. Objectives in this area follow those established by the National Council of Teachers of Mathematics:

* Operate a computer independently;
* Use a variety of quality software;
* Call on (command) a repertoire of trouble-shooting skills to correct simple computer operating difficulties;
* Solve problems, mathematical and others;
* Analyze information generated by a computer program;
* Organize information;
* Manage information;
* Judge the suitability of a particular piece of software for a

specific purpose;

* Represent and process visual information;

* Given a problem, decide if a computer is a useful aid when compared to other side or approaches to solving the problem;

* Write and edit text;

* Write and modify simple computer programs.

Throughout all the various activities of the program, evaluation is done on a continuous and regular basis. In addition to a standard report card, a special student progress report is built directly around science process skills. Pre-tests and post-tests are used frequently and a major common test is administered during the tenth and thirtieth weeks of the year. The first of these common tests stresses lower level skill acquisition while the second delves more deeply into higher level processes. All results are discussed with students and with parents. Conferences, self, and peer evaluation occur frequently.

STRENGTHS AND WEAKNESSES

Goals -- The major objectives of the zoo compponent coincide exactly with the SESE criteria and would be considered definite program strengths. The highly interdisciplinary nature of our approach, the real career and work settings provided by the Zoo, the Museum and the research libraries, and the careful attention to "learning how to learn" as a life-long skill receive careful planning consideration and each has supporting activities. The one relative weakness might be that although psychomotor skills are a regular part of our hands-on approaches they are more incidental to it than are specifically planned.

Curriculum and **Instruction** -- All SESE criteria coincide closely with Zoo Component program objectives and specific activities. Science processes and the scientific method provide the program's unifying theme. Practical applications, everyday experiences, societal issues, and career awareness are each major and continuing topics. Student interests and levels of sophistication vary, so the program has individualized activities and strategies.

Teachers -- The teachers enjoy working with students in these grades. Their basic operating premise assumes that students are knowledgeable and responsible. Although specific preparation in teaching science to early adolescents has been minimal, experience, cooperative planning, and continuous evaluation of results have all helped turn this area into a relative strength. The teacher's role as a trusted adult who can be relied upon for stimulation, response, and direction, the emphasis on particular teaching techniques (laboratory settings, small groups, and individual conferencing rather than constant lecture), and the reliance on specialized resource personnel for in-depth research or experimentation have all been factors which help teachers assume the position of broad generalist with a strong grasp of applications, possible careers, and appropriate technology.

Evaluation -- This aspect of the program is continuous, pays close attention to individual differences and growth, and focuses on program

success as well as student success. Self-evaluation, peer evaluation, parent involvement and awareness, teacher evaluation, and evaluation by "outside" resource personnel all provide facets which help fill-in the picture. These criteria, then, would also be strengths of the Zoo Component.

FACTORS CONTRIBUTING TO SUCCESS

In a major cooperative program between the public schools and public community resources, full and complementary participation by all involved parties is a necessity. Good, continuous communication, ongoing parent involvement, and the coordination of activities, transportation, and the roles of different personnel contribute to success. Financial and philosophical support, enthusiasm, hard work, and commitment also contribute. These areas involve people, and all the various groups are critical.

Constant curriculum development and revision occur frequently, demanding the supportive help of school district resource persons and consultants. The more comprehensive the planning, the better the chances for success.

Overall, the major factors for success result from the interaction of all these components, especially the students and teachers, in a truly cooperative learning "adventure." Facilities, materials, and equipment are of secondary importance. They may enhance the opportunities available but **people** devise, plan, invent, improvise, adapt, and take full advantage of those opportunities.

EVIDENCE OF PROGRAM REPLICABILITY

The Buffalo Zoo provides a critical center of focus for the activities of this program. At first glance, one might think that any community with a similar facility could implement such a program. And while this might be true, consideration should not be limited only to such communities.

There could be a variety of single community resources which might be enlisted as cooperative partners for a science program of this nature. Alternatively, a network of several resources -- farm, research facility, college or university, observatory, aquarium, science museum, or division of parks -- might be formed to provide the hands-on, practical focus.

This program has improved now that some of its facilities are complete. These include the new building to house students at the Zoo full-time, new electronic and technological capabilities, and additional resource personnel. However, while these may be significant additions, they are not all "necessary." The fundamental core of this program involves a **cooperative** group of **people** -- teachers, students, parents, school district personnel, and community resource persons -- who share goals and who share commitment. Their effort, enthusiasm, creativity, expertise, curiosity, and mutual respect form the keystone of the program. These factors are "replicable" and could serve to establish a similar, adapted program in almost any community. It might not be easy but it is very possible.

EVALUATION OF SUCCESS

When considering a non-traditional program such as this, one must turn primarily to repeatedly-observed behaviors and longer-term perspectives for evaluation of major goals. Those goals focus on attitudes and conceptual understandings different from the simplest levels of cognitive achievement which are tested by most standardized measures.

Certainly in the four years that this program has existed students **have** improved their standard test scores in reading, writing, and mathematics. As an example, last year's seventh grade class showed 50% of the students below grade level in reading. Those same students, now in eighth grade, currently show only 6% below grade level in reading! But this is not the true test of program success.

Consider instead the professional observations noted by the Zoo Component teachers when they listed specific and consistent behavioral changes of their eighth grade students now compared to those same students when they entered the program as seventh graders:

* Students in all subject areas now use reference books before seeking teacher assistance.

* Students readily seek and accept criticism -- including peer evaluation.

* Students normally seek and recognize patterns.

* Students are now comfortable with divergent thinking, conflicting theories, or several points of view on a particular issue and evaluate the validity of each.

* Students commuicate in a variety of forms with an air of of "collegiality" and support replacing competition and self-consciousness. Even students with speech problems competed in the recent Richmond Speaking Contest.

* Students now revise their written work as part of a standard process without teacher direction and use peer evaluation as a revision tool.

* Students readily accept increased responsibility for their science fair projects and exhibit greater independence in the the completion of those projects.

Consider also the observations of persons who have examined the program. The District's Director of Science, the District Supervisor of Language Arts, and parents report very positive feelings about the program. The increased quality of student work, the highly positive student attitudes toward school and each other, and the daily enthusiasm of students participating in the program lead us to feel we have a very successful program.

Chapter 5: PRIS2M

By

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Rochester, a city in upstate New York with an urban population of 260,000, is the center of a metropolitan area with a population of nearly 971,500. This third most populous metropolitan area in New York State is the home of Eastman Kodak, Xerox, Bausch and Lomb, Sybron Corporation, and other companies which employ technically proficient professionals and skilled workers.

The Rochester Community School District total enrollment of 34,761 includes 19,413 elementary school students in 30 schools, 14,479 secondary students in 30 schools,and 869 students in elementary and secondary alternative education programs. Minority students comprise 61 percent of the District enrollment.

The basic program of science instruction, called R.I.S.E. (Rochester Integrated Science Education), provides a general education for grades K-12. The Elementary level program consists of a K-6 scope and sequence that integrates the components of a textbook with hands-on process, writing, and language arts activities to reinforce the instructional objectives. PRIS2M (**Program for Rochester to Interest Students in Science and Math**), is being piloted this year in the comprehensive Junior-Senior High schools. Our high school component, U.S.E.-Rochester (**Unified Science Education for Rochester**), links philosophically and instructionally with the other levels by treating science in a holistic or integrated fashion. The underlying beliefs of the R.I.S.E. program are that:

* Science is a way of learning about the world we live in.

* Science knowledge can be generated through the application of process skills.

* Students learn science best by actively "doing" science.

* Grade level placement of activities should be consistent with recent research regarding developmental levels of learning.

Each of the three components of the R.I.S.E. program uses student and teacher guides correlated with materials kits. Course content is determined by the needs and characteristics of the learner, community expectations from business and industry, and a basic commitment to scientific literacy for all our students.

Interested and intellectually capable students can specialize in science in the secondary schools by electing additional N.Y.S. Regents courses including Earth Science, Biology, Chemistry, and Physics along with a variety of advanced placement science courses.

OUR DEVELOPMENT

The Program for Rochester to Interest Students in Science and Mathematics resulted from a national challenge to increase the number of minority students capable of becoming successful engineers. Willis Sprattling, a senior official with the Xerox Corporation and a member of the National Advisory Committee for Minorities in Engineering, brought the challenge to the Board of Directors of the Industrial Management Council of Rochester. Soon after, the IMC established a task force to evaluate the challenge locally and, if necessary, to establish a plan. PRIS2M is the result of this extensive evaluation effort.

Located in a high technology center, the City School District realized a very low number of minority students elected to take science courses, with even fewer majoring in science and mathematics. In two mostly minority high schools, we found a total of five students taking physics in 1978.

With almost 40 percent of the Rochester workforce employed in industry (a total of about 140,000 people) based on technological products and services, there is almost no heavy industry here. As a consequence, technical and engineering skills are in great demand. Because so few minorities ever consider engineering as a career, opportunities for this segment of our population to acquire positions leading to professional and managerial rank are limited. Education and industry have joined to increase the number of minorities majoring in science and math so that more students will eventually be available to Rochester's high-tech industry.

Funded and managed by the Industrial Management Council, nearly all of PRIS2M's programs take place within the City School District with the full support of the Board of Education and Superintendent of Schools. In fact, one-third of the Board of Directors of PRIS2M is made up of school district personnel. One-third represents the Rochester community while another third represents industry. This total group provides a considerable resource beyond that of the specific program activities. People, materials and "in kind" contributions play a significant role in our total program.

Increasing the number of minority students capable of entering engineering schools and successfully completing engineering programs represents the greatest challenge and the ultimate goal of the PRIS2M program. Necessary building blocks include a variety of pre-college programs and activities considered to be both motivational and academically

supportive in nature. These range from a general curriculum development effort impacting on all City School students at the junior high level to specific activities for selected minority students at six comprehensive high schools and several special summer science programs.

The number of Rochester students electing to take more than the required science unit during their high school years represents a tremendous lack of interest in science. In 1978, 10,000 students were enrolled in high school in RCSD but fewer than 300 were taking a physics course. Obviously they weren't interested in the science programs we had to offer.

Newly developed programs for the non-science major were beginning to reverse the trend. A new program for elementary school youngsters provided considerable direct learning experience and increased enthusiasm. However, students leaving the middle/junior high demonstrated the greatest loss of interest in science as indicated by the low enrollment in high school science courses. During 1979, PRIS2M developed several supplementary science units. Although optional, these units have realized considerable success in many classrooms, particularly those where the teacher was involved as one of the authors working on the program.

In 1981, the City School District requested PRIS2M to expand their curriculum development effort, to produce a complete seventh and eighth grade program which would link both the elementary and the new high school programs. Necessary preparation for such a major curriculum effort at the junior high school included establishing a base of current research on the middle/junior high student. We found the NSTA publication, "Science and the Adolescent," to be particularly useful. Further, we reviewed NAEP and NSTA documents on science education -- relevant to junior high schools. Dr. Michael Padilla, a science education research specialist, presented an update on current research plus several curriculum development ideas for junior high school science.

Within the City School District a steering committee was developed, including representatives from each junior high school who had expressed particular interest in the junior high student. Guidelines developed by this group were integrated into those from Padilla, NSTA research, and the original PRIS2M curriculum materials. Following this, a writing staff, selected entirely from the School District applicants, began the writing process.

The developmental reorganized the original set of 12 enrichment units was expanded to provide 9 units of instruction at each grade level. During August 1983, more than 20 junior high science teachers and administrators received an intensive two-day workshop conducted by the developmental team in preparation for pilot implementation. At this time there are approximately 600 junior high students in 27 classes experiencing PRIS2M 7 and 8 curricula in the RCSD.

OUR PROGRAM

The PRIS2M curriculum provides an exciting, meaningful, relevant educational experience as an alternative to the often highly theoretical, content-based, abstract, rigidly structured, and overly lectured science courses which probably account for the tendency or students to lose interest in science prior to entering high school. Built around recent research recommendations by the National Science Foundation on the nature

of the early adolescent, along with considerable research on the way adolescents learn, this curriculum motivates while emphasizing the development of basic science process skills, problem solving, and critical thinking.

The boundaries between the disciplines of science are dissolved in PRIS2M in order to deal more effectively with the nature of science; scientific concepts, processes, problems and phenomena; issues and careers in science; and the interrelationships between science, technology, and society.

Fully recognizing that the vast majority of middle/junior high students function at a concrete operational level, the PRIS2M curriculum is a highly manipulative, materials-intensive program designed almost totally around the development of **basic skills, integrated process skills,** and **problem solving skills** drawn from a wide range of disciplines.

Unique curriculum-related features include a requirement that students identify and carry out a long term science-related study. Teachers are also required to "role model" the scientist, becoming personally involved in some form of science research. Required process skill units are intertwined with units teachers may select, either from their own repertoire of teaching experiences or from alternative PRIS2M units. Students, too, have some choices within each unit.

Unit tests are both analytical as well as instructional. Students use their unit evaluation results to assist in the identification of areas (skills) which require further development. These needs may be immediately attended to by the selection of appropriate activities in the subsequent PRIS2M unit.

The emphasis on basic science skills development in the seventn grade program is followed by an eighth grade program emphasizing integrated process skills at a slightly higher sophistication level.

Curriculum Plan

Each course has nine instructional units and one on-going connective unit. PRIS2M 7 and 8 program materials include a curriculum guide for teachers containing the teaching strategy of the program along with individually packaged unit materials kits. Cognitive, affective, and psychomotor evaluation instruments have also been designed for the program.

Program Goals

The most important goal of the PRIS2M program is helping teachers to help children learn about mathematics and science. From the very beginning we wanted to state clearly what children will achieve through their studies in this science program. Before establishing a list of intended outcomes, the PRIS2M directorship polled the scientific community to help formulate a set of educational convictions upon which the development of the curricula would be based. The convictions agreed upon include:

* Children work best when trying to find and answer problems that they themselves have chosen to investigate;

* Problems are best drawn from the local community and environment;

* Problems should be tackled in a practical manner using the process skills of science;

* Teachers should be responsible for thinking out and putting into practice the selection of work for their classes and personally model the use of scientific concepts, methods, and values;

* A curriculum should reflect integration of the sciences;

* A variety of learning modes should be incorporated to accommodate the many learning styles of the students;

* Ample choices should be made available for students as well as teachers regarding what and how they learn;

* The curriculum should develop specific knowledge and manipulative skills through concrete, hands-on learning experiences;

* The curriculum should be designed with the needs, characteristics, and developmental level of the learner in mind;

* The F.U.S.E. (Federation for Unified Science Education) model for curriculum development is the most viable format for designing a curriculum that allows these conditions to prevail.

Program Orientation

The development of the PRIS2M 7 and 8 curricula follows the F.U.S.E. model for curricular design. Inherent in this model is a philosophy that views science as a unity and emphasizes the development of scientific literacy. Scientific literacy includes:

* Understanding the nature of scientific knowledge;

* Applying appropriate science concepts, principles, laws, and theories in interacting with the universe;

* Using processes of science in identifying and solving problems, making decisions, and furthering an understanding of the universe;

* Interacting with the various aspects of his universe in a way that is consistent with the values that underlie science;

* Understanding and appreciating the joint enterprise of science and technology and the interrelationships of these with each other and with other aspects of society;

* Developing a richer, more satisfying, and more exciting view of the universe and continuing to extend this education throughout life;

* Acquiring manipulative skills associated with science and technology.

PRIS2M instructional units move students in a positive direction along the continuum of scientific literacy in all three domains of learning and human behavior: affective, cognitive, and psychomotor. In the affective areas, five objectives have been generally identified as areas for evaluation;

* Appreciation for the unity of science;

* Understanding the nature of science knowledge;

* Recognition of the contribution of science to society and the attributes of scientists;

* Awareness of the values that underlie science;

* Increased positive self-concept in science.

In the cognitive domain, emphasis for evaluaton will center around:

* Knowledge of scientific concepts;

* Application of science process skills;

* Problem solving ability.

The psychomotor outcomes will be assessed in the areas of:

* Laboratory skills (manipulative skills);

* Communication skills.

From this skill-based program, academically oriented students will be better prepared for success in high school courses while non-science majors will have attained a degree of scientific literacy considerably broader in scope than would be attained in a reading-based textbook program emphasizing a few limited concepts. As a result of PRIS2M's emphasis on the interdisciplinary nature of science, a multitude of career opportunities can be recognized. Throughout the curriculum, entire student modules are designed to increase student awareness of the important role that a science/mathematics background plays in future career opportunities.

One expectation is for students to make decisions. Opportunities for choice are provided by alternative modules within every major PRIS2M unit. Many modules generate open-ended problems, the solution to which is not defined. Even the unit test results are to be used by the student to enhance problem solving skills. After each test, a performance profile is shared with each student reflecting growth in content and skill areas. This immediate feedback allows each student to be able to make decisions for self-improvement. In this way, more of the responsibility for learning falls in the hands of the learner and leads to a more individualized science education.

PRIS2M has developed an extensive evaluation plan assessing cognitive, affective and psychomotor outcomes related to overall program objectives. Extensive pre- and post-testing in all three domains, along with continuous teacher feedback sessions and unit test scores, provide considerable evaluative information. Locally developed instruments are used in conjunction with a nationally standardized testing program (CTB McGraw-Hall). Congruence of treatment and control groups is established through pretesting along with matched demographic data and math and reading scores collected from district-wide testing using Metro 78. These results will form the basis for curriculum revision workshops already in progress and will in turn provide a refined, more effective product.

Several PRIS2M Curriculum Highlights Include:

* Improving basic and integrated process skills including problem-solving on the part of middle/junior high students;

* Learning to make appropriate choices within the curriculum content and skill areas by selecting alternate activities designed to strengthen specific student weaknesses;

* Placing the student in the role of a scientist by requiring a variety of direct problem-solving experiences and one long term scientific study to be carried out during the school year;

* Increasing student awareness of the importance of having a strong science/math background for both the academically oriented student and for the non-academic student who will probably be seeking employment in an increasingly technological society;

* Improving student attitudes toward science and math by providing direct involvement in studies which are of interest to middle/junior high age students and which have a high likelihood of success;

* Establishing the science teacher as a role model scientist by actively involving the teacher in some form of research activity, the results of which are assessed by the students as to the processes used and conclusions drawn.

In striving to meet criteria for excellence we have worked hard to:

* Encourage students' independent use of skills and practical problem identification and solution.

  Learning modules in PRIS2M strive for open-endedness. Extensions of each activity depend upon students' responses while teachers listen and question rather than explain authoritatively each unfamiliar concept or topic.

Each student identifies a long term project based on a self-designed investigation and arrives at conclusions.

Each teacher role models the scientist in the classroom and demonstrates, by example, the skills of inquiry.

* Help students learn how to learn, including cognitive, affective, and psychomotor aspects.

  Pre/post testing is carried out in all three domains. Even the cognitive test items are operationalized as process-type questions being "clearly above recall" in design.

  Unit tests are diagnostic as well as summative for each student. A performance profile given to each student after each test helps to focus on areas of weakness in subsequent units.

  Subscales, on the affective inventory, test for the appreciation of the skills of science as tools for lifelong learning. Unit modules are designed to reinforce this concept.

  PRIS2M curricula are materials-intensive, allowing students to interact with a wide variety of tools, instruments, and science "things."

  Communication of ideas in the form of tables, charts, graphs, dialogue and written composition are all explicitly provided for in the learning modules. The "THINK WRITE" component of the curricula requires a daily written "debriefing" on the part of each student.

* See that students gain an academic background which encourages career decisions and which serves students who will nor pursue further formal science education.

  PRIS2M 7 and 8 modules include a wide array of science concepts, problems, processes, and phenomena. The quantity and diversity of these experiences far surpasses those that students have been receiving in a single-discipline-based program.

  The Industrial Management Council of Rochester provides industrial role models whenever requested. In this way students realize the direct link that their education in science has with the world of work. There are over 650 role models available for this purpose.

  While all units impact on specific themes such as CITY LIVING, the underlying and pervasive instructional approach is inquiry, using the process skills to solve problems.

* Develop student attitudes which result in appropriate decision making.

  Intensive inservice training of the writing team regarding attitude development preceded each writing session. Each item on the Affective Inventory was created by consensus during the developmental phase of PRIS2M 7 and 8, keeping attitude development foremost on the minds of the writers as each learning module was created.

  Subscales of the Affective Inventory include; a) understanding the nature of science, b) appreciating the unity of science, c) awareness of the contributions of science and scientists to society, d) appreciation of the values that underlie science, and e) self-concept in science.

* Emphasize science in interdisciplinary and work settings.

  This model is organized around themes common to all disciplines or that can be viewed from a variety of science contexts.

  The strong emphasis of PRIS2M 7 and 8 on the "doing" aspect of science and its connection with everyday life, industry, and technology are fundamental to the philosophical approach of the program.

CURRICULUM

The curriculum emphasizes science processes and inquiry while science topics are explored at a general and interdisciplinary level. The underlying instructional philosophy is directly geared to the development of curricula that emphasize the processes of science exercised through a variety of science contexts, teaching modes and levels of difficulty.

We use practical applications and everyday experiences, including issues in science and society, career awareness, and historical aspects of scientific thought.

PRIS2M 7 and 8 learning modules, by design, connect with the real world of the student. When possible, role models provide career awareness and deal with issues in science and society. While issues are brought to our students attention and openly discussed, the teaching staff is careful to let alternative sides of the issue have equal weight. Historical antecedents are frequently used to introduce science concepts. For example, Galileo and the swinging lamp introduces the pendulum and properties of pendular motion.

Throughout the field testing of PRIS2M 7 and 8 units, careful notes on how well modules are received by students and independently derived ideas by students are used in the curriculum revision process.

We recognize that students at various levels of cognitive development need a range of topics, activities, and strategies. Needs and characteristics of the emerging adolescent and process skills development for middle/junior high school students are considered. With this background, each writer developed diverse sets of modules using many different modes of learning, in a variety of science contexts offering choices, and a range of difficulty so the student would have a better chance for success.

Instruction

Instruction emphasizes a variety of strategies, logical sequencing of activities, concrete experience, and a "hands-on" approach. The PRIS2M program uses the list of eighteen "Modes of Learning" as identified by research done at the University of Ohio. Each unit incorporates a mix of modes to accommodate the varied learning styles of our target population.

Where possible (especially in process units) logical sequencing of activities has been stressed.

The PRIS2M program is materials-intensive. Each unit is supported by materials kits. The "hands-on" approach is personified through the PRIS2M program.

The recently established R.I.S.E. Center (Rochester Integrated Science Education Center which services programs K-12 including E.S.S. K-6, PRIS2M 7 and 8, and U.S.E. Rochester 9-12). handles the refurbishment, distribution, and scheduling of materials kits for approximately 30 classrooms district-wide in the program. This Center is modeled after the Fairfax County Virginia Science Materials Center, and has resulted in a very cost effective management system in support of these curricula.

Our units focus on student success in learning. Built in choices allow students to be co-determiners along with their teachers regarding what and how they learn.

Unit tests are specifically designed to be used as a learning component rather than being the punitive culmination of a learning experience.

The opportunity for students to move ahead on their own is provided for through the individualized assignment of alternative activities throughout the curricula. The mix of modes of learning accommodates the variety of learning styles and assures that all students will experience some degree of success. Selection of organizing themes for individual units is based in part on topics that are relevant to the target group and are inherently interesting to them.

Teachers make optimal use of community resources, including field trips, independent study, and interaction with people who are role models. Modules are designed to emphasize local environmental conditions, industrial complexity, institutions of higher learning, museums, and science centers.

More than 650 role models from local businesses and universities have been identified and are available to PRIS2M students. These role models perform several functions including tutoring, general discussions, judging contests, lecturing on specific topics, and career guidance.

The Rochester Council of Scientific Societies has provided support to the PRIS2M program in terms of recognition for achievement by students, help for teachers in modeling-the-scientist-in-the-classroom, and advice for the research and preparation of student activities for competition in the local Science Congress (Science Fair).

The development of a number of specific non-commerical items used in the instruction of PRIS2M curricula have been designed and produced by various members from the Industrial Management Council of Rochester. These items are incorporated into the individual unit materials kits at no cost to the program.

Teachers

An intensive inservice plan nutures a philosophical concensus regarding the unity of science among participants. Inservice upgrades teachers' awareness of varied science applications and roles for technology and career opportunities. Additional activities connected with the PRIS2M program reinforce the emphasis on roles for technology and career opportunities e.g., PRIS2M "Teams," and summer programs.

Inservice training focuses in part on the needs and characteristics of the emerging adolescent student. Recent research on brain growth periodization, development of process skills in middle/junior high school students, along with theories of developmental levels of learning and human behavior are among topics dealt with in teacher training.

We improvise, adapt, and invent appropriate instructional strategies and resources and match them to student abilities, backgrounds, and interests. The entire PRIS2M program has been created by teachers utilizing their collective experiences for module ideas and activities that they know work with these students.

Constant curriculum evolution takes place in each classroom. Teachers understand that the printed module guidesheets provide a well thought out set of activities that serve as points of departure. It is incumbent upon each teacher to assess the needs of the class and contribute anything that is required to facilitate the learning process.

Formal revision of program units incorporates feedback from all pilot teachers. They are asked to critique each item, recommending changes, or deletions and are expected to share their own ideas for more suitable or effective modules.

Teachers relate to students as responsible individuals, being sensitive to moods and needs, and possessing a sense of humor. Teachers must enjoy being middle/junior high school science teachers and see the importance of their profession. The organization, design and philosophical approach used by the PRIS2M curricula has changed the quality of the classroom experience for many teachers. By following the tenets of the program many frustrated teachers are achieving success in a situation that had always been difficult. The change in teacher and student expectations fostered by the program has resulted in a number of unexpected but welcome outcomes in this area of concern.

EVALUATION

Evaluation is directly related to the goals for both process and product. A specialist in the evaluation of science programs has been commissioned by the project to work with the staff to develop a comprehensive evaluation scheme. This scheme is designed to be formative for the project development and summative for overall program and student evaluation.

Our evaluations consider differences in cognitive abilities, maturity, and background. Unit tests provide a performance profile for each student. This information is used by the student and teacher to select appropriate learning activities in subsequent units.

Pre- and post-testing is used to evaluate each student. In this way each student's achievement is measured against his/her starting point on the continuum of undertanding, knowledge, and skill.

Effective evaluation leads to improvement in quality, efficiency, effectiveness and functioning of the program. It reflects awareness of local conditions, restrictions, limitations, possibilities, and potential. Program evaluation utilizes teacher feedback, student reaction, and implications from the formal testing program. Each test question is item analyzed for quality as well as for indications that the program is or is not successful in achieving its purpose in that area. All this information is considered throughout the revision process. This input will determine the development of new units, modules, teaching strategies, or inservice training components.

Our evlaution process includes teacher evaluation. Teacher evaluation occurs through self, peer, student and administrator observations.

Input from all realms of the educative process are sought by the project staff, parents, and community leaders. While this aspect is informal it is nonetheless important to the continued refinement and success of PRIS2M.

FACTORS CONTRIBUTING TO SUCCESS

Success of the PRIS2M program depends in large part on the concerted efforts of the Industrial Management Council of Rochester, the leadership in the Division of Instruction of the Rochester City School District, and other interested community organizations including the University of Rochester, Rochester Institute of Technology, and the Rochester Council of Scientific Societies. All of these groups have come together with a common purpose; to elevate the educational and vocational aspirations of the students of the City of Rochester through the development of highly motivational and educationally significant programs in the area of mathematics and science.

Other factors contributing to the success of the PRIS2M curriculum include the involvement of local research professionals in science and math who serve as role models. Local private industries have provided financial support, contributed materials, funded writing teams, and printed student module guide books. Increased awareness and appreciation for science education and its related career opportunities in local industry seem to benefit both the educators and the industrialists in the Rochester area.

Inservice is a fundamental component contributing to the success of PRIS2M. In order to implement the change in science teaching that PRIS2M demands, a comprehensive well designed inservice plan has been adopted. In essence the model has several distinct components:

* Assessment of need;
* Planning for action;
* Training of development teams;
* Training pilot teachers;
* On-the-job implementation;
* Feedback from evaluation and pilot teachers;
* Planning for revision.

Each of these components have been faithfully carried out and recycled over the years of program development. The success of the inservice plan is directly attributable to the fact that interested and involved individuals have participated extensively in all phases of the process.

The recently established R.I.S.E. Center (Rochester Integrated Science Education Center which services programs K-12 including E.S.S. K-6, PRIS2M 7 and 8, and U.S.E. Rochester 9-12) will provide additional incentive and cost savings through its function as a materials acquisition, and distribution depot. The R.I.S.E. Center will also articulate the delivery of printed materials and media along with the materials kits for the anticipated 70 PRIS2M junior high school classes that will be taught during the 1983-84 school year.

TRANSPORTABILITY

The PRIS2M 7 and 8 curriculum was initially developed to provide a set of highly motivating instructional units that would serve to support and enrich existing seventh and eighth grade programs in a few selected classes in the RCSD. Enthusiastic response by the students and teachers using these materials prompted the Department of Curriculum Development and Support, to expand the program to include all six comprehensive Junior and Senior High Schools in the use of these materials. The question of implementation on this broader base demanded that the curriculum be designed so that the various local school conditions would not present insurmountable problems to implementation. In a sense, school-specific and teacher-specific techniques had to be eliminated from the curriculum to make it applicable in all settings. Accommodation to RCSD mandates regarding homework, reading and writing reinforcement, and the development of critical thinking skills in all RCSD curriculum development efforts also served to make the PRIS2M curricula generalized enough to preclude the necessity of specific conditions for implementation.

As with all new science programs that demand extensive use of manipulatives, the program of materials availability had to be dealt with. The PRIS2M leadership has provided prototype materials kits that contain all necessary consumable materials along with some unique equipment not usually found in every school's science inventory. While an effort was made to use as many common and readily obtainable items such as toothpicks, food coloring, paper cups, straws, and the like, as possible, it was decided that by placing as many items in refurbishable kits, the likelihood of modules being taught as intended stood a greater chance of happening. Kits for all PRIS2M 7 and 8 units are available from the newly established R.I.S.E. Center.

Another specific design component of the curriculum that helps provide for implementation in diverse settings is the way in which the instructional materials are packaged.

* All 9 units at each level contain complete Teacher's Guides providing detailed information regarding the philosophy, instructional strategies, use of materials, correlation of reading, writing, math and critical thinking skills with the modules, evaluation techniques, and answers to all module and test questions.

* Teachers receive curriculum guides in large loose-leaf notebooks that allow worksheets to be removed for duplication. This format also allows modules to be replaced, revised, updated, and added to as new insights to the unit are gained

through evaluation and teacher feedback. This format also provides an easy means for making activities district-specific. One of the tenets of this program is a commitment to continuous curriculum evolution.

* Class sets of student guides are available through the CSD Book Depository at cost for local schools. These items would also be available for purchase by replicating districts, along with Teacher's Guides and evaluation instruments.

* A well-trained cadre of Teachers/Trainers consisting of project staff and pilot teachers has been formed to provide in-depth inservice training for both seventh and eighth grade levels. This team would be available for establishing a replication workshop.

* Kit inventories can be used to build kits or complete kits can be purchased from the R.I.S.E. Center.

* Built-in teacher and student choice in selecting activities in each unit eliminate the problems of having to do specific modules that may not be appropriate for replicating districts, or that do not match locally developed instructional objectives. These curricula have provided more than 150 percent of the materials needed to teach a full year of science. This was done specifically so that choices can and must be made to accommodate individual teaching situations and student learning styles.

All of these characteristics serve to help implement PRIS2M in the diverse schools of the RCSD and would certainly add to the transportability of the PRIS2M program to interested districts.

CHAPTER 6: ENVIRONMENTAL PHYSICAL SCIENCE

By

Robert Ewart

Lower Moreland Middle School
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Accessible by several main highways and two railrod lines, Lower Moreland Township, a suburban residential community adjacent to the city of Philadelphia, has slowly evolved from an agricultural base to an industrial base to the present day residential, out-commuting community of approximately 12,000 inhabitants. Inadequate public transportation and the abandonment of farm land have led many Blacks to seek employment elsewhere with the resultant decline in the number of Black residents.

The location and economic condition of the community suggests that the percentage of occupations of professional, managerial, proprietory, official, technical, and skilled categories will continue to climb.

The school district, comprising all of the township, enrolls 2130 students, but the district is experiencing a significant decline. We have three buildings, a K to 4 elementary school, a 5 to 8 middle school and a 9 to 12 high school. A professional staff of about 50 teachers serves the middle school.

The Middle School, in existence since 1967, currently houses 754 students. A decline in enrollment of about 100 students a year is anticipated for the next two years until a stable point is reached at about 550 students.

The Environmental Physical Science program gives young people an opportunity to study their environment from a scientific and social standpoint. The students choose areas of environmental study which are of interest to them, conduct investigations into the problems of the environment, choose methods to measure the effect of these problems, and study various solutions to these problems. The program takes a topic relevant to today's young people, makes them aware of the problems affecting their environment, and gives them the background to tackle these problems in a scientific way.

This program uses a physical science approach to study the environment. However, since the seventh graders entering this program do so with a background and interest in life science from their experiences in sixth grade, several of the packets lean heavily on the biological and ecological aspects of the environment. Also, since these seventh graders will take earth science in the eighth grade, there are several packets which treat this area in an introductory way. This course provides the students with an awareness of their environment, the skills and concepts of physical science, and a bridge between the biological and earth sciences.

OUR PROGRAM

Our program emphasizes scientific literacy while giving students a strong foundation in science. In the process, we want students to:

* Understand the processes of science;
* Produce laboratory reports in an accepted format;
* Have active involvement in laboratory procedures;
* Understand simple weather characteristics and the instruments used to measure them;
* Understand basic concepts and vocabulary of general physics and chemistry;
* Recognize major characteristics of atmospheric pollutants;
* Understand the manner in which man attempts to correct unsatisfactory conditions resulting from atmospheric pollutants;
* Appreciate environmental quality derived from studies in the nature center.

The program encourages practical problem solving and inquiry by its organization. The textbook used presents a series of problems and then activities to solve those problems. Also, every unit has a series of related activities for the student who wishes to pursue certain topics in depth.

We encourage experimentation, written lab reports, and debates and discussions. A debate on the merits of the returnable bottle laws is part of the solid waste unit and newspaper recycling is promoted through a community collection system. The students survey the community on current environmental issues and discuss the issues with elected officials. This activity emphasizes appropriate decision making.

The curriculum and instruction emphasize science processes from the first unit. Activities illustrate the scientific method and lab report format. Metric measurement is reviewed as a basis for studying the environment. The students must design a simple experiment and complete a lab report.

Ecology is explored next in the program with ecosystems providing the basis for the study. Extensive use of a nature plot behind the school occurs, permitting immediate application of classroom topics such as abiotic and biotic community, diversity, and density. The students are required to search out examples and use them in lab booklet activities. A field trip to the Schuylkill Valley Nature Center permits a further extension of their knowledge into a larger, more varied outdoor facility.

Weather emphasizes historical developments up to present advanced satellite reporting systems. Each student learns all the atmospheric conditions reported by meteorologists and the instruments used to do so. Indoor instrumentation is explained and daily records are maintained, illustrating one of the ingredients of modern forecasting.

Interested students volunteer to prepare daily forecasts for the school using the computers, instruments, and their own weather maps.

To show additional practical use of this knowledge contacts are made with local weather forecasters and guests are invited to share their interest in this science field. Daily scientific forecasts are shown on television monitors to teach how daily weather maps are formulated. These activities show people working at science and make it relevant to their everyday experience.

Chemistry, although one of the more difficult units, is very popular with the students. The experiments are many and varied, illustrating the inorganic principles of elements, molecules, compounds, and mixtures.

Chemistry topics are presented with perspectives from the alchemists to the newest discoveries of today. A highlight for those with artistic talents is an original design for their individual lab book covers.

Early units give students the basic knowledge they need to study the environment; specifically, land, air and water. This unit concludes the basic science portion of our seventh grade science program.

The solid waste disposal unit studies a very current topic. This unit was developed from the closing of the dump in Lower Moreland in 1971 when the state declared the site illegal. This introduction to the problem begins a focus on the larger problem in the country. Possibly the federal government attempting to clean up toxic waste dumps throughout the United States.

Locally, the students design an experiment to weigh the refuse produced from their homes in Lower Moreland. Then they extrapolate to illustrate the size of the problem on a larger scale. Current disposal methods are illustrated and new technologies presented. A major project as part of this unit is the community wide recycling campaign.

Students' artistic talents are encouraged during National Wildlife Week. Each student must make a poster to illustrate in any art media the theme for the year. The staff sponsors a contest for the best poster. This activity gives many students a chance to succeed in a different learning situation.

The Air Pollution Unit uses acquired weather, ecology, and chemistry knowledge. As sources and types of pollutants are reviewed, the students chemical knowledge enhances the discussion of various chemical pollutants. Air pollution problems are related to atmospheric conditions and geography, as well as local emissions sources. Temperature inversions are demonstrated with appropriate equipment in the classroom. A miniature electrostatic precipitator illustrates the use of current technology for controlling air pollution.

Students are given a historical perspective from the first serious problems in the 1950's to the present conditions and the effects of current laws. Current newspaper accounts of air pollution problems, especially in California and locally, are monitored along with daily pollution measurements reported in the newspaper. The local conditions are measured through individually designed experiments and matched with daily weather conditions to determine any measurable relationships.

The social effects of a population that demands electricity at a cheap price and, up till now, with little regard for people's health, or the environment are debated. The subject is the "Four Corners" Project in the middle of rural Indian country.

The water pollution unit has a large outdoor segment using a stream that meanders through the nature plot behind the school. After exploring the unique properties of water, the abuses of our waterways are illustrated visually through films loaned by the EPA and our local instructional materials service. An audiovisual approach is used throughout the program as an alternative strategy in the classroom.

A hands-on approach explores the outdoor site with the chemical test kits. Various sites are manned by different groups and all the results are tabulated and illustrated from year to year. These activities teach the students how to follow directions and organize a stream study. Living members of the ecosystem are sampled and recorded by groups as evidence of the health of the stream.

Water pollution control is emphasized along with the laws to control it. The trade-off between corporations and jobs, and expensive pollution control and clean water is addressed. The fight for stricter laws is debated, and the improvement of many waterways is noted.

A new unit on energy has been added. Limited sources of energy are shown which force decisions on society about energy consuming life styles. Management of our present resources, as well as future alternatives, are presented.

Penn State University supplies speakers on the energy crisis and students have a chance to use a special computer to manage the remaining resources on earth with the resulting consequences.

Students write creative stories and cartoons which tap student imagination about the day when energy sources as we know them, cease to exist.

Through all the units, knowledge gathered and reported through the scientific method leads to responsible decision making. The technological progress of society is balanced by its care for the environment.

Teachers

The program is team taught by a certified and well qualified staff. Robert Ewart, who teaches most of the seventh grade had a part in rewriting the program, has a masters in environmental education. The other person teaching in the program is Roger Fetterman, who has a specialty in physical science and earth science. Innovative ideas are shared and implemented, and flexibility is a key to adapting daily to the many activities of the middle school child.

Innovative approaches include the use of: department made textbooks, lab booklets, the classroom reference library, community library, weather station, nature area, films and filmstrips, tapes, and a computer simulation.

The science staff capitalizes on the varied backgroud of its members. They are a team dedicated to the middle school child. Every effort is expended to offer a caring structured environment permitting individual growth. Classroom rules are set up to teach respect for each other and the learning process. Students are allowed to experience the consequences of their actions within defined limits. The teachers can laugh with the students and help them to build confidence in themselves. Every opportunity is available for a student to better themselves and experience greater self worth.

EVALUATION

Consistent with the middle school approach, evaluation of students is varied and includes all parts of the students' participation in the program, both process and product. A varied approach in class includes lecture, demonstration, debates, written work, creative activities, discussions, experimentation, and indoor and outdoor experiences. Students experience both formal and informal including student led activities. The evaluation must be flexible to match the program and the student, including tests and quizzes and daily log evaluation. Also, lab booklet work, oral and written lab reports, observations, and participation are used. Special help is offered, especially to special education mainstreamed children. Each child experiences some success.

Formal progress reports are issued four times a year and informal interim progress notices are also issued. Most improved and superior progress awards are made. Parents are given opportunities to be knowledgeable about the program and their child's progress.

The staff is observed and receptive to peer and administrator contructive criticism on a regular basis. The students are given the opportunity to evaluate themselves and comment on the program from their point of view.

Very positive program evaluation has resulted. Several key points demonstrate this clearly:

* Parent response has been supportive and enthusiastic. This has been demonstrated by their concern for student achievement and comments on parent open house occasions and conferences.

* Students consistently show enthusiasm and interest by their participation and success in the program. This is shown by their progress and comments which are written four times during the year.

* Recognition has come from outside the community from the NSTA. Teachers of the program presented it to a seminar of teachers from across the country during the NSTA national convention in New York City in April 1981;

* Teacher evaluations have often indicated the effectiveness of the program through comments about the value of the activities and student responses.

* An annual newspaper recycling program shows the support of the community and the 100% response to students' surveys about township participation in recycling programs.

* Students have acquired the ability to write basic lab reports and perform the scientific method.

STRENGTHS AND WEAKNESSES

The strengths of the program are activities which help children better understand their role in shaping their environment. This is accomplished through activities which follow the scientific processes. The conclusions which students make must consider the ramifications to themselves and others.

The introduction of creative expression into the science program provides another area of strength. The intent is not to sacrifice a student's creative talent for the good of the whole class. The program allows expression in terms of written words, music, drama, or art to allow maximum opportunity for expressive creativity.

Another strength of the program is the emphasis on helping the child achieve and maintain an interest in science and what scientists are currently doing. This program takes advantage of the relevance of the subject matter for motivation and the structure of the program itself to generate new interest in science and the work scientists are doing.

An improvement in the program for more interdisciplinary work could be implemented if staffing and schedules permitted. The program could be expanded in several areas into other disciplines beyond what is already done. A teaming organization of grade levels would facilitate this.

A more formal approach to role models engaged in the field of scientific inquiry might be desirable. A day of various career talks could be scheduled for the seventh grade, as is done for the eighth grade, or more guest speakers could be invited.

The extent to which individualized instruction is realized has been limited by staff restrictions. The program has the potential to be individualized further, with smaller class size and increased staff -- both professional and support personnel.

HISTORY OF THE PROGRAM

The Environmental Physical Science program has its roots in the interest and enthusiasm of the seventh and eighth grade students who attended the Middle School during the 1969-1970 school year. During this time, a science club formed by these students undertook a project to establish an outdoor education laboratory on land behind the Middle School. Students cleared debris from the area, discussed potential uses of the tract, and attempted to map the area. While doing research for the mapping, the students discovered the land belonged to the Frederick Company and not the school. On their own initiative, they wrote to the Frederick Company and received permission to use the land as a nature center until such time as the company might need the land for future expansion.

At the same time, changes in national attitude toward the environment began taking shape. With Rachel Carson's **Silent Spring**, attention was being focused on problems of pollution and environmental decay. This

interest began to invade the school and led the science club to propose an Earth Day program for April 22, 1970. The entire school participated in the day's activities. Students attended poster and song contests, speeches, and a series of workshop presentations. The interest shown by the students and the degree to which they made their feelings about the environment known, led members of the science department at the Middle School to consider the role of environmental studies in the curriculum.

This consideration was heightened in October of 1971, when it was announced that federal ESEA Title III funds were being used to establishh an environmental science consulting service to serve schools in the five country Philadelphia area. This group, called Project KARE, was offering fourteen grants to local school districts for the implementation of a community oriented environmental studies project. The Middle School science department decided to write a proposal for funds for a project to study the township's sanitary landfill which had been closed by the state for violations of the State's Solid Waste Management Act. The proposal, written by Jacquelyn Volk, Thomas Wittkamp, and Roger Fetterman, established Project REFUSE (Revitalize the Environment for the Future Use) which was to involve about ten teachers and forty to fifty students. After school activities were drawn from the areas of art, social studies, English, math, and science. It was during the writing of the proposal that many of the activities and projects which were later to become the backbone of the EPS program were first discussed. The project turned out to be one of the seventeen funded by Project KARE and began operations in January, 1972.

During the summer of 1972, Tom Wittkamp and Roger Fetterman volunteered their time to determine the feasibility of developing a physical science oriented environmental studies program using the material and equipment from project REFUSE. The work took the form of a course of study dealing with ecology, water, and air pollution. Behavioral objectives were written for the three units, material to be taught was organized, and classroom activities and projects were developed. The end result was the first draft of the Environmental Physical Science curriculum. The program was inquiry-oriented and stressed a "hands on" approach to dealing with the environment. The focus of the program was the Outdoor Education Laboratory, developed by the science club a year before.

With the Middle School philosophy of individualization in mind and with the success of the previous year's independent study program, the authors of the EPS program proposed to develop a series of individual learning packets to cover the EPS material and to provide for a wider range of activities for the students. Money was made available for a two-week curriculum writing session. The end result was a series of eight learning packets dealing with the environment and related topics. The course was used with nine top and middle track sections during the 1973-74 school year. The results of this trial were evaluated and the program was put in this final form during the summer of 1974.

After two years of working with the packet form of the program, a new revision was necessary. Several aspects led to this need. First, without the help of a teacher's aide, effective classroom management of a completely open approach was difficult. Second, the packets and much of the equipment needed replacement from hard use. Third, a need arose for a better student record keeping device. Finally, after working with the program, some activities needed to be rewritten and revised.

The latest revision was concluded during the summer of 1977. The improvements included a format of units bound together to replace the old packets. Problems and activities were made a part of each unit. Related activities were included at the end of each unit. This permits an independent approach or a teacher-centered approach or a combination. The units were reproduced in a single booklet. A lab book was added with worksheets corresponding to activities in the units. A more thorough introduction was also written to present material relating to each problem. This revision was first used in the fall of 1977.

Minor revisions and additions continue to take place within the units each year. These include a major newspaper recycling program each year, a weather forecasting service for the school, and integration of the use of computers wherever applicable.

The most recent major change was the development of a comprehensive Energy Unit to replace a water treatment unit.

QUALITIES NECESSARY TO THE PROGRAM

Like any successful program, a variety of factors are critical. We see two as being especially essential.

* The current nature of subject matter.
  The unit titles alone point to the current nature of the material. For instance, the unit on solid waste disposal includes the mounting problems of rapidly filling landfills and toxic waste dumping. Included is a newspaper recycling project and a returnable bottle debate. Emphasis is placed on promising waste disposal programs that produce heat for various purposes. Air pollution is discussed in a separate unit. The merits of the present air pollution laws are discussed, while new laws are passed in the states and Washington, D.C. Car emission inspection is being debated in Harrisburg. Sampling of the air in and out of the school for pollutants is accomplished. Water pollution is another timely unit, as the struggle for cleaner streams, rivers, and oceans goes on. A stream is tested behind the school for chemical impurities and the diversity of living things.

* High interest topics.
  These contribute to the program's success along with activity oriented classwork. The program has outdoor segments in several units, including ecology. A diversity and density study is accomplished in a wooded area behind the school. The weather unit is a combination of outdoor and indoor atmospheric instrument studies. A highlight is the class and school wide forecasting done with the help of the school computers. Chemistry grabs the student's interest with an Air is Matter Study and sustains it through the unit with a series of experiments with oxygen, hydrogen, mixtures, compounds, and acids and bases.

Even with these two factors, relevance and interest, there are still items needed to keep the program going. These include:

* Equipment

  A variety of weather instruments for indoor and outdoor recording. Chemistry equipment for simple demonstrations and gas production experiments. Also, equipment for mixture separations and basic chemicals, including metals, acids and bases, and acid-base indicators. Air pollution testing equipment and chemical water testing equipment from La Motte is used in these units.

* Reference Material

  Several supplementary book series are written into the program for certain units. A good library is a requirement for research with up to date information on the environment.

* Texts

  Our 207 page locally developed text is one of the essential pieces of the program. A lab booklet, keyed to the text, is another essential consumable for each unit.

* Cost Factors

  Costs for the program; other than resource materials such as filmstrips, reference books, and textbooks; are mainly consumables. These consist of the lab booklets, chemicals, outdoor sampling equipment for ecology and water studies, plus consumable materials in the La Motte chemical test kits for air and water pollution.

REQUIREMENTS TO TRANSPORT TO OTHER COMMUNITIES

The program was developed especially for the Lower Moreland Middle School and is unique for that reason. However, the basic outline of the course can be adapted to other areas. The success will depend on the resources available and the creativity of those teaching the program.

An outdoor study area with a small stream or pond is important to the ecology and water studies units. A lab for experiments is desirable, but table tops and alcohol heaters will work for chemistry. An area to set up weather recording instruments is desirable. Storage is mandatory. The program can be carried out with students of various levels and in various physical settings.

CHAPTER 7: 9TH GRADE EARTH SCIENCE

By

Thomas P. Knorr, Sr.

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The Pen Argyl Area School District serves the rural communities of Pen Argyl and Wind Gap and Plainfield Township in a rural setting. The Pen Argyl Area Junior High School connects via a tunnel to the Pen Argyl High School. Located in Northampton County near the northern border at the base of the Blue Mountain, the Junior High School includes grades seven through nine, serves a student population of 475 and includes a staff of 27 teachers, one guidance counselor, and one principal.

The ninth grade earth science program at Pen Argyl Junior High School implements innovative teaching techniques in addition to traditional methods to develop basic concepts. The program provides a good balance between learning and applying concepts. The students apply the basic concepts they learn to solving problems with real world application. The students apply their knowledge using the scientific method in predicting the weather, determining geologic processes in the field, determining the suitability of a landsite area for development, and making decisions about the proper utilization of our energy resources. Students acquire the knowledge needed to act as responsible citizens, develop an appreciation for the complexities of scientific work, and at the same time, have an opportunity to explore various earth science careers.

All ninth grade students at Pen Argyl Junior High School must successfully complete the earth science course. The classes normally average 28 students which accommodates our laboratory oriented course. A balance between the knowledge and skills and the application of knowledge to solving problems using the scientific method guides the instructional strategies of the course.

GOALS

Upon completion of the earth science course all ninth grade students will:

* Complete successfully as judged by the outcome of laboratory and field tests at least 70% of the laboratory and field investigations on meteorology and geology which involve following written and verbal instructions, manipulative laboratory skills, making mathematical computations, constructing and interpreting graphs, making accurate observations and drawing conclusions;

* Successfully demonstrate in essay, objective and problem tests a level of understanding of meteorological and geological concepts necessary to develop a comprehensive understanding of the earth sciences, deal with related day-to-day problems and act as responsible citizens;

* Successfully predict the weather for at least four consecutive days during one class period for a twelve hour period for the Pen Argyl area using the 12 Hour Weather Forecasting Test by applying meteorological knowledge and models to local observations and weather maps;

* As a class, successfully evaluate an area of land through research and appropriate field techniques and decide as to the acceptability of the land for purchase and development;

* Successfully solve geological problems in the field as judged by the outcome of written geologic field trip tests by applying geologic knowledge acquired in the classroom and laboratory to observations made in the field.

COURSE OUTLINE

Meteorology

The Atmosphere, and the Solar Energy Machine, and Household Applications
Water in the Air
Atmospheric Pressure and Wind
Weather Mapping
Weather Forecasting Models and Principles
Weather Forecasting
Relationships between Man and the Atmospheric Environment
(integrated into each section above)

Geology

Volcanism
Diastrophism and Earthquakes
Weathering, Mass Movement, and Soil Studies
Erosion and Sedimentation
Ground Water
Oceanography
Plate Tectonics
Rock and Mineral Identification
Topographic Mapping
Local and State Physiography
Local and State Geologic History and Paleontology
Landsite Evaluation

Geologic Field Studies
Economic Geology and Fossil Fuels
Relationships between Man and his Geologic Enviornment
(integrated into each section above)

Astronomy
Solar System

OUR PROGRAM

Although the course outline separates units of study, the units frequently interrelate. These interrelationships between concepts provide for better understanding and frequent exposure to a given concept.

The earth science students use the textbook **Earth Science** by Namowitz and Stone for reference, reading and written homework. The real core of the program depends on the printed materials, laboratory investigations, independent learning units, visuals, field trips and other activities developed over the past 16 years.

In developing the conceptual background needed for future application, teacher directed class presentations encourage continual student participation and feature the essential ingredient of any successful learning experience -- a knowledgeable, motivated, and concerned teacher. Many of these presentations involve discussions of current events and issues. Through these discussions students see how these events and issues are related to the earth sciences. Excellent teacher made visuals and demonstrations support these presentations. Demonstrations help clarify difficult concepts and those not suited for individual investigation. During the demonstrations, students make observations, ask questions, and determine the underlying principles involved.

The students complete 30 meteorological investigations, 20 geologic investigations, and five astronomy investigations; most are "hands-on" activities. A laboratory and resource book, written ten years ago, contains the meteorological investigations, weather models and weather forecasting principles. The geological investigations in modular form allow a great deal of flexibility and include the CEEP modules on plate tectonics developed by the National Association of Geology Teachers. The investigations involve student observation, measuring, recording, classifying and communicating data. In addition, the investigations provide the student with an opportunity to observe basic principles in operation and also allows them to form space-time relationships developing more in-depth understanding of the concepts.

In addition to the difficulties our students have with some of the concepts, many also have reading and mathematical deficiencies. To help reduce these deficiencies, individual learning units have been developed. The units incorporate the use of slide viewers, tape players, and written materials along with student participation. At the conclusion of the independent learning unit, the student completes a self-correcting follow-up exercise.

After the students acquires the necessary concept foundation, numerous opportunities to apply their knowledge in "real world" situations exist. In meteorology, after the study of heat transfer, the students study and observe methods of reducing heating costs in the home to promote energy conservation. Each student takes home a handout to review with his/her parents.

After the study of the earth's solar energy machine, the students complete an investigation using a portable solar collector which allows them to observe the principles of solar energy utilization. The students then measure the heat output of hot air and hot water solar collectors that actually help heat the earth science classroom.

During the study of meteorology, learning activities provide the basic physical concepts needed to understand the dynamics of the atmosphere. However, since all students will need to deal with the real weather and forecast the weather, an understanding of day-to-day weather changes is essential. Six years ago, five United States maps, large enough for students to see anywhere in the classroom, were designed for presenting an entire week of weather maps and local conditions. Map symbols indicating fronts, highs, lows, air masses, kinds of precipitation, and other meteorologic conditions are placed on the maps by attaching magnetic strips to the back of colored cardboard. Daily, local observations are placed directly below each map on the chalkboard.

Each day, for a period of ten to fifteen minutes, students discuss the changing local conditions and their relationship to the United States Weather Map. For many months the daily weather helps relate the physical concepts developed during class discussion and laboratory work. By the end of the week, the students can observe movement of highs, lows, and fronts across the United States. This experiential knowledge provides the foundation for applying physical concepts to the "real world" of changing weather.

In preparation for the weather forecasting test the students, through the assistance of an independent learning unit, learn the **Weather Forecasting Principles.** To reinforce these principles, the students play the **Pen Argyl Grand Prix,** a game which tests and reinforces the **Weather Forecasting Principles.** The students play the game a few times in class and then on their own time in either the resource room or guidance office. This game has proven to be very effective, especially for the slow learner.

Prior to the time when the students practice weather forecasting and then finally do the forecasting as a testing situation, the students view and participate in a program called **A Weather Scenario** which gives the students an opportunity to observe and study a winter snow storm. In addition to the charts, maps, local conditions and homework, slides show the changing sky conditions prior to, during and after the passage of the low. Throughout the presentation the students see many relationships between the local observed conditions and the large scale conditions depicted on the weather map. These changing conditions are related to the meteorological models and priciples found in their laboratory notebooks. The students see for themselves which models relate well to actual changes that took place and those which do not always work. This exercise also familarizes the students with the **12 Hour Weather Forecasting Test.**

The final exercise in the study of meteorology involves the **12 Hour Weather Forecasting Test** which all ninth grade students complete in four consecutive days. Students apply the scientific method in analyzing the local observations, charts, information from NOAA weather radio, and various weather maps from **A. M. Weather.** This exercise allows the students to experience the complexities and difficulties in predicting natural phenomena and has an observable effect on their scientific attitudes.

The unit on geology continues to reinforce the application of the scientific method. First the entire class evaluates an area of land in respect to its suitablity for purchase and development. Items researched, observed and evaluated include geologic, environmental, social and political factors. Each student has an opportunity to research and complete field work in the areas of the study that interests him the most. Collectively, the class makes the final decision after analyzing all of their findings.

Finally, the students complete geologic field exercises. The ninth grade students participate in an all-day geologic/interdisciplinary field trip in May. Prior to this field trip, the students complete **A Field Trip to the Bear Valley Strip Mine**, a simulated, in-class field trip. Parts of the exercise are completed in class and other parts as homework. The students use actual rock and fossil specimens, black and white photographs, maps, colored slides and other laboratory materials. The students make the necessary observations, analyze their findings and determine the geologic processes that produced their observations. This exercise is thoroughly reviewed in class and prepares the students for the geologic field trip.

During the geologic portion of the trip, the students visit three main sites where they make observations and then hypothesize the geologic processes that occurred at each site. The students observe and study an overturned bed of dolomitic limestone containing ripple marks, an intrusive sill that cut through shale and produced hornfels through contact metamorphism and a cave with solution cavities and some precipitation features. The students determine these conclusions through the use of a well organized, sequential question-answer sheet and a field trip guide book.

The teacher-chaperones serve as resource persons to provide help and hints without providing the answers. The trip provides students with the opportunity to explore many basic geologic processes that demonstrate the nature of the dynamic earth.

After the geologic portion of the field trip, the students choose a number of options for study which relate science to other disciplines. This allows the students to see how science relates to a subject like history, and gives them an opportunity to satisfy their own personal interests.

The trip is extremely well organized and has only had minor problems since its inception thirteen years ago. Evaluation includes written tests, rock tests and surveys to measure student outcomes and viewpoints.

The **Rockville Field Trip** is completed after the geologic field trip in much of the same fashion as the Bear Valley field trip, except that it incorporates the use of landsite photographs, stereo photographs, and topographic and relief maps.

In conclusion, as the students use the scientific method throughout the year, they also become "meteorologists" and "geologists" in the process. This develops not only knowledge and better understanding, but just as important, it develops scientific attitudes necessary for responsible citizenship in a changing society.

STRENGTHS AND WEAKNESSES

The earth science program strongly matches all the criteria for excellence. Inadequate facilities make implementation difficult but not

impossible. The earth science classroom, one of the smallest science rooms, has very limited storage facilities for both laboratory equipment and printed materials. To allow the program to be successful, many hours must be spent after school because the classroom is not available for setting-up demonstrations, organizing laboratory investigations, and other organizational tasks during school hours. A lot of improvising and administrative cooperation in improving the facilities has made it possible to overcome most of the difficulties.

DEVELOPMENT OF THE PROGRAM

Thomas Knorr, Earth Science teacher, developed the program over the the past sixteen years. Before he began teaching at Pen Argyl, the course emphasized memorization of facts and involved little laboratory work. Some equipment was available but some necessary apparatus and instruments were subsequently purchased. Mr. Knorr provided most of the printed materials and specimens which lowered the operating costs significantly.

The **Earth Science Curriculum Project,** followed with some classes during the early 1970's, provided some ideas but did not meet the needs of our students. In 1979 our school participated in field testing the **Crystal Evolution Educational Project** sponsored by the National Association of Geology Teachers. The progam uses several CEEP modules at the present time.

Using available resources and facilities, the program has evolved into a smooth running course. An important factor leading to successful implementation has been the excellent cooperation provided by the school's administration. Also, Dr. L. W. Clark, one of the school's guidance counselors with an excellent geology background, has been involved with both the ninth grade geologic field trip and the very successful geology club with its many diversified activities.

CONTRIBUTING FACTORS

The earth science program is a cooperative effort. The other earth science teacher, Joseph Carimanica, follows the curriculum and activities developed by Thomas Knorr. The district contributes to the overall success through its cooperation and adequate funding of laboratory and field activities.

For the program to continue its success, the program requires continued funding. The laboratory and field activities cost the district around $2.00 per student each year.

UTILIZATION BY OTHER SCHOOLS

Thomas Knorr has over the years, communicated many of his ideas and techniques to many earth science teachers who have successfully incorporated them into their earth science programs. The laboratory work uses typical, inexpensive apparatus and materials available in most science facilities. Most of the teacher made projects require inexpensive, readily obtainable, and easily fabricated materials.

The sources of up-to-date information and data for meteorology include **A. M. Weather** and NOAA weather broadcasts. **A. M. Weather,** an excellent fifteen minute program on many public service television presents numerous

different weather maps of the country. Almost all schools in the United States can receive a NOAA weather radio which provides an excellent source of meteorological data, especially if a school does not have the needed instrumentation.

EVALUATION

Success in the earth science program can be shown through the interest developed in students who have participated in advanced studies. Between 1979 and 1983, sixteen students have chosen to do more advanced study in geology. These students have participated in our geology club and have been involved in many activities including field studies in Pennsylvania, New York, South Dakota, Wyoming, Utah and Arizona. We have also conducted an exchange program with members of a geology club from Pleasantville, NY. This exchange program not only diversified their geologic field studies, but also provided an opportunity for cultural exchange. Students prepare for the field work by completing laboratory exercises on geologic mapping, mineralogy, petrology, and stratigraphy during the school's activity periods. The students have shown a great deal of enthusiasm and have done remarkable work for high school students.

Between 1980 and 1982, a solar energy workshop was conducted during our activity period. Students with varying levels of abilities and skills, constructed three active collectors and one passive solar collection system.

In 1981 Thomas Knorr received the "outstanding science teacher award" from Sigma Xi Club of East Stroudsburg State College for "his enthusiasm and original course and curriculum development."

Chapter 8: 5-8 GENERAL SCIENCE

By

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The science program at the E. T. Richardson Middle School can easily serve as a model for other schools exploring ways in which they can tailor science courses and materials to the special needs of their own student population. Nationally developed instructional materials have been adopted in a manner that is realistic and effective, while core science content and activities stress mastery of basic process and inquiry skills. Emphasizing hands-on activities to reinforce underlying learning objectives, student performance is identified in terms of major competency areas which focus on knowledge, skills and attitudes.

The interdisciplinary team structure of the school provides numerous opportunities to enrich the basic science program. Team projects range from focusing on specialized areas of the curriculum to broader experiences such as those dealing with career awareness.

The success of the science program at the E. T. Richardson Middle School is the product of appropriate curriculum selection, team organization, staff commitment and competence, and strong District supportive services.

OUR PROGRAM

The Springfield School District resulted from a merger of Springfield Township School District and the Morton Borough School District, Delaware County, Pennsylvania. The Morton Borough is bounded on three sides by Springfield Township, approximately eight miles from downtown Philadelphia in an area that has changed during the last thirty years from a primarily rural-agricultural area to a suburban residential community. Proximity to Phildelaphia with its cultural and educational institutions and the industrial and business opportunities makes Springfield typical of many of the so-called "bedroom" communities surrounding our larger cities. Our

township of 36,000, served by a number of large highways, bus, and railroad facilities, enjoys easy access to the metropolitan area. Mainly middle or upper middle class, our residents tend to work outside the geographic area of the District, either in Philadelphia or the industrial complexes along the Delaware river running from Chester to Philadelphia. The Springfield School District, composed of two elementary schools (K-4), a middle school (5-8), and a high school (9-12), has a total school population of 2,900 students.

The middle school provides for a gradual transition from elementary school to secondary school.

GRADE FIVE: Fifth graders participate in unified studies. Working and planning together, two teachers instruct a group of fifth graders in reading, science, mathematics, social studies, and language arts. Student movement between classes is minimal.

GRADE SIX: Sixth graders come into contact with a teacher in each of the four academic areas. Reading is taught as part of the instructional team on a cycle basis. Students take art, general music, industrial arts, or home economics on a daily basis for a nine-week report period and then rotate to each of the other three subjects the following periods.

GRADE SEVEN: Seventh graders receive instruction in the academic areas from four teams of teachers. The academic areas consist of science, mathematics, social studies, and English. Instruction in special subjects is received on a cycle basis and foreign language is offered as well.

GRADE EIGHT: Eighth graders also receive instruction in the academic areas from four-teacher teams. They are scheduled for their special subjects on a cycle basis and may choose from fourteen electives for three of their cycle periods.

GOALS

In the Springfield School District the middle school science program represents the vital link between the elementary and high school levels. The major objectives or goals of the program are strongly consistent with those which have been identified for contemporary science education. With its emphasis on process and inquiry skills, the program provides students with a wide range of experiences designed to increase individual competencies in identified knowledge, skill, and attitude areas.

CURRICULUM

With the exception of the grade five curriculum, core content at each grade level is represented by nationally developed instructional materials. Grade 6 uses (S--APA), grade 7 (IMB), and grade 8 (IET). An energy education emphasis in fifth grade is supplemented by selected S--APA exercises. This S--APA component provides a continuum from the elementary science program through grade 6, reinforcing learned process skills. A separate career education strand is found at each grade level.

Although the core curriculum is uniformly taught throughout the respective grade levels, the basic content and experiences are supplemented by additional instructional materials designed to enrich and expand the science program. For example, **Concepts and Challenges in Life Science** (Bernstein, et al, 1979) is used as a supplement for the grade 7 Life Science program (IMB) and **Concepts and Challenges in Earth Science** (Bernstein, et al, 1979) is used in a similar manner in grade 8 Life Science (IET).

Instruction

The noteworthy character of the E. T. Richardson science program can be traced directly to our team teaching concept. Team teaching is itself a living model of individualism, for through the sharing of planning time, materials and ideas, team teachers can make the best use of all their resources.

Teacher strengths can be matched to instruction. While teachers maintain special areas of knowledge, they get the benefit and stimulation of other teachers' ideas. As they work together, teachers gain respect for one another's talents and ideas, and their professional growth as educators is greatly enhanced.

With teams composed of teachers of different subjects responsible for teaching and counseling a common group of students, team teaching provides maximum understanding and cooperation with the adjustment and development of the child being the primary concern of the team. Students see each teacher contribute personal expertise to a common goal. Students also see that a team cares enough about individual students to work together to help them solve a particular problem.

One product of team planning is the development of interdisciplinary projects. Typically, an interdisciplinary project enriches the students' experience while responding to special student needs. Content focus can range from specialized areas of the curriculum to broader experiences such as those dealing with career awareness. Local resources including outside speakers and large group presentations are frequently used. Special field trips which reinforce the learning objectives are not uncommon. Two such grade level projects are the P.E.E.C. experience and the Crum Creek Watershed study.

All middle school science classes, grades 5-8, meet for five forty-five minute periods each week. The eighth grade cycle course, astronomy, meets for nine weeks and may be repeated, depending upon student demand with an average class size of 23. Classes are heterogeneously grouped and all special students are mainstreamed. The average number of students in a team is 98.

Teachers

The success of the E. T. Richardson Middle School science program can be attributed to the quality of the experienced teaching staff. While the majority of the science teachers are certified in elementary education, all of the staff have additional training in assignment related content areas. An examination of the quality of the curriculum and interdisciplinary projects indicates a high degree of commitment and professional competence.

Regular systematic classroom observations by the building administration and the science supervisor substantiate that the science instruction is strongly student-centered and congruent with the established curriculum.

EVALUATION

Student performance is determined through a variety of common procedures. Science notebooks are required in grades 6, 7, and 8 and all laboratory activities and student activity sheets are graded and returned promptly. Quizzes, tests and final examinations are a regular part of the program. The S--APA component (grades 5 and 6) have a built-in compentency-based element.

Over the last several years, there has been a concerted effort to identify major competency areas at each level. These competencies, matched with performance indicators, provide an evaluation which closely matches course goals and objectives.

Student success is directly related to program effectiveness. Teachers are continually assessing the activities and content and both administrative and supervisory input are regularly provided.

STRENGTHS AND WEAKNESSES

The E. T. Richardson Middle School science program provides a wide range of student experiences designed to emphasize fundamental process and inquiry skills. The instructional emphasis is on student-centered activities with hands-on concrete experiences a regular part of the classroom environment. The team organization of the middle school provides numerous opportunities for expanding the science curriculum through interdisciplinary projects. The middle school science teachers are of high quality and they are committed to working with children in this age group.

Areas of the program which can be identified as in need of improvement include the need to "fine tune" the evaluation process. Printed instructional materials are due for review and additional strategies for working with special students need to be identified and implemented. All of these areas will be examined during the next two years.

PROGRAM ORIGIN

In the Springfield School District, the science supervisor has the major responsibility for providing leadership in the coordination and articulation of individual planned courses among staff across grades, goal areas and buildings (K-12). In science, the District is philosophically committed to a uniform, sequential curriculum. This curriculum is periodically reviewed by the District-wide Coordinating Committee for Science and/or its appropriate subcommittees.

The science courses in the E.T. Richardson Middle School have as their core an externally produced curricula. But in no case were these materials adopted and used directly. It was only after course goals and selection criteria were defined that curriculum materials were examined and selected. Once adopted, these materials were used and modified on the basis of classroom experience and teacher feedback. During this process grade level, department or subject level meetings were especially important in

tailoring the curriculum to the special needs and characteristics of our students. Staff involvement in the curriculum management process is maximized. For example, all sixth grade teachers are members of the subcommittee which studies sixth grade science. Professional days and special workshops facilitate these activities. The science teachers participated in several summer curriculum workshops related to the selection, implementation and maintenance of the respective courses.

Chapter 9: 7th GRADE LIFE SCIENCE AND 8th GRADE EARTH SCIENCE

By

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The city of San Marcos, mid-way between Austin to the north and San Antonio to the South, has a population of 25,000, almost two-thirds Mexican American.

Small non-polluting electronic firms, Southwest Texas State University, Brown Schools, Aquarena Springs, San Marcos Baptist Academy, Gary Job Corps Center, and the raising of livestock are the principal industries in the area.

OUR PROGRAM

Goodnight Junior High School, with 855 students, is the only middle school in the community that serves our AAAAA high school. Laboratory study is planned and coordinated to follow the curriculum for the Life and Earth Science courses giving our students the hands-on approach to understanding concepts discussed in the classroom. We have a full-time lab teacher, certified in Life and Earth Science, operating out of one completely equipped laboratory. In addition to helping us save money and space, this enables the lecture teacher, while the class performs lab activities, one full day out of every six to work on curriculum development, our greenhouse and plant care center, lab manuals, lab program, standardized leveled examinations, inservice, and other concerns. Much of our program is skill leveled. We administer a pre-test over basic skills to every student in May. Using these scores and a science teacher's recommendation, each student is scheduled into a leveled science class at the beginning of their seventh and eighth grade year. An effort is made to have at least two, and preferably three, levels taught concurrently each period. This allows flexible movement of students between levels. Our program gives each student enough hands-on experiences with the scientific

method that their confidence in problem-solving will be reflected in and out of the science classroom. All labs and class activities include observing, measuring, inferring, predicting, interpreting data, controlling variables, and experimenting. Every student rotates through the science laboratory every sixth school day. This insures that every student in the school participates in a minimum of twenty-seven laboratory experiments during each of two years on our campus. In addition, every student participates in several long-term projects in their regular science classroom. Students study earthquakes, weather, stars, and other topics or work on a greenhouse project.

The curriculum, rather than textbook bound, uses multiple adopted texts. Following a locally developed curriculum guide and using a variety of resources, the textbooks (2-3 classroom sets per room) are used only as reference material. The curriculum emphasizes and stresses the seven major concepts of observing, describing, quanitifying, organizing, predicting, tasking, and generalizing outlined by the National Science Teachers Association. The curriculum includes many vocational/avocational experiences including lapidary skills, star/planet watching, animal care, live student broadcasts over our local KCNY radio station, garden/greenhouse experiences, and a computer resource room. Mastery learning techniques using many modes of learning and varying time limits are provided so that all students can be expected to master basic skills. The leveled curriculum program provides the opportunity for teachers to work with gifted students in competitive science experiences such as science fairs, the Texas Junior Acadamy of Science, and two Science U.I.L. meets each year. The curriculum includes many field trip experiences. Every seventh grader spends a day at the San Antonio Zoo while all eighth graders have a field trip to Natural Bridge Caverns and the San Antonio College Planetarium. Eighth graders also participate in five star watch field trips to Wimberely in the spring. These night time classes allow students to work with teachers to complete a Star Diary contract.

The program takes advantage of interdisciplinary projects. The Art department makes clay flower pots on the potters wheel for the Life Science students for planting. These plants are then sold and monies divided between the art and the science departments as a means of perpetuating the program. Industrial arts classes aid us in building astrolabs, animal cages, bird houses and feeders for the outdoor learning center, and in the maintainance of the weather station. Language arts and reading teachers coordinate reading and writing skills with the Science Star Diary requirements. Special education teachers team teach on a daily basis in low level classes. This allows special education students move through the science program just as regular students do. However, each resource or special education teacher works with a science teacher in their classroom every day to help adapt and modify activities for the special education students.

The science curriculum at Goodnight focuses on the development of the skills of observing, recognizing and using number relations, measuring, classifying, communicating, inferring, predicting, formulating hypotheses, interpreting data, controlling variables, and experimenting. These skills, practiced daily, develop confidence in problem solving strategies that are effective in or out of the science classroom. To achieve such skills a variety of materials and activities such as experiments, demonstrations, lectures, films, filmstrips, slides, transparencies, field trips, models, discussions and problem solving are used.

FACTORS CONTRIBUTING TO SUCCESS

The teachers in the program are highly motivated and very hard-working. They have a wide variety of life experiences and hobbies that directly relate to the Life/Earth science curriculum. Good, open communication occurs between teachers, students, and administrators. The team teaching approach involved with the lab program allows for the assimilation of the best ideas and information that each teacher has to offer. The program forces teachers who would not normally provide laboratory experiences into a hands-on, experimental approach, avoiding total reliance on a text. The responsibility for the success of this program lies on the very motivated, experienced teachers. The program would not be a success without a group of teachers willing to give of their time and talents. But the program is hard for new teachers to assimilate. The information, the scope, the sequence of the program, and the scheduling restraints take about one year to learn. The additional time off offered to each teacher every sixth school day has to be very carefully monitored in order to maximize the benefits to the program.

DEVELOPMENT OF PROGRAM

Goodnight Junior High School, built in 1969 originally housed seventh, eighth, and ninth graders. From 1969 until 1976 we had six science teachers, three science laboratories, and adequate equipment for one classroom of 30 students. For all these years, only two of the six teachers used the laboratory facilities and the equipment. We operated on a yearly budget of $300,000, collecting a $1.50 laboratory fee each semester from each student.

The initial funding of the laboratory equipment came from a Federal Block grant when the school was built. Fee collections were discontinued in 1972 and maintenance of the program has continued through local budget means. Our anticipated budget for the next year is $3,000.00 for general supplies, $2,000.00 for field trips and $500.00 for equipment repair.

In 1976, there was a district-wide push to write a coordinated and challening science program with which students could be successful. The program was to be activity oriented, hands-on, and emphasize the discovery processes.

The science faculty visited John Jay High School where a lab program under the direction of Mary Helen Bunting and Peggy Carnahan was in operation. With staff and administrative commitment, the next year we skill leveled into average, basic, and enriched classes, wrote labs and activities for each level, developed leveled tests over each lab, released a science teacher from a regular class load absorbing the extra students and began the process of writing a science curriculum. For the past six years the lab program has been written, re-written, and revised.

Now we have a strong, central core of experienced teachers who enjoy junior high students and the curriculum they teach to the point that much of their leisure time and interests are spent with students and with hobbies that complement what they teach. In school or out, our teachers are involved with underwater photography, scuba-diving, lapidary work, gardens, and greenhouses. While we have only one science laboratory room with tables, gas, and water outlets and equipment for thirty students we now have one full-time laboratory instructor. Teachers enjoy an average

class size of 25 students (fewer in the low levels and as many as 32 in the high levels) and the additional release time each six school days for every teacher to work improvements. Mastery learning practices and skill leveling allow students to achieve mastery and experience a great deal of success at a level relevant to their abilities. The curriculum focuses on the seven science concepts identified by National Science Teachers Association; therefore, expected goals and behaviors are consistent throughout all classrooms at all levels. Our curriculum includes vocational and avocational aspects such as greenhouses and gardens, animal care and feeding, lapidary work, computers, and weather broadcasting over local radio stations. The science curriculum includes interdisciplinary activities as well.

EVIDENCE OF SUCCESS

School finances are tight for most school districts in Texas. Yet, we definitely need to provide students with a meaningful science experience regardless of facilities and finances. After developing a lab-lecture program which offers every student in our school such an experience, our rotating lab schedule, one laboratory room, one lab teacher, complete lab equipment, standardized and leveled experiments, plus our success over the last seven years have become an attractive package for other schools interested in upgrading their science program and facilities.

Round Rock schools evaluated our approach to science and have decided to build their new facilities in a manner that will aid them in implementing a similar model. Schools in the Northside district of San Antonio, Seguin, and Aldine in the Houston area have purchased our first lab manual and are very interested in all the positive aspects of implementing our program in their schools.

EVALUATION

Students like our program. Seventh and eighth grade students rated 75% of the labs they participated in as Okay to Great. The average gain of all eighth grade students on the science section of the C.T.B.S. test for the past several years has been 2.5 years. The average score for last year's eighth grade class on the science section of the C.T.B.S test was 9.7. Inquiries into the organization and development of our lab-lecture program by Seguin, Round Rock, Houston, and San Antonio are positive indicators that other schools are interested in starting similar programs. In January, 1982, the Texas Education Agency accreditation monitoring team visited our school district. The following commendation was written: "The science program in the junior high school is one of the strongest ever observed by this monitoring team, expecially in terms of its planning, coordination, execution, use of laboratory and field experiences, and its cooperation with the mathematics department for the benefit of all concerned."

Chapter 10: LIFE SCIENCE, EARTH AND PHYSICAL SCIENCE, AND ENVIRONMENTAL SCIENCE

By

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In 1972 Michael Salvesen and Lynn Archibald came to South Cache Junior High School as science teachers for the 7th, 8th, and 9th grades. Lynn had one year of teaching experience at North Cache Junior High and Mike had just completed a masters degree in Plant Physiology at Utah State University. They replaced a teacher who had quit and a teacher who had transferred to another school within the district.

When school started that first fall, the new teachers were shocked at the attitude of the students toward science. It almost seemed as if they hated the word "science." This came as a real surprise! The new teachers expected the students to be as excited about science as they were. Students had been exposed to a very passive textbook approach where they would read the chapter, answer the questions, take a test, and then hurry on to the next chapter so as to complete the text by May 25th. Combining this approach with very little equipment and a complete lack of teaching aids like filmstrips and overlays does not produce an exciting science program. The new teachers worked hard those first few years in changing the students' poor image of science, and several solutions began taking shape.

The second year at South Cache the new teachers requested and received a larger science budget. They went to Ken Webb, the Assistant Superintendent, requesting financial help for references like nature guides, National Geographic reference books, overlays, and field guides. Also, they purchased a complete set of Swift microscopes over a period of several years. They constructed a weather station, bought mineral, rock, and fossil specimens from all over the world and purchased a reflecting telescope to study the night sky. The South Cache Media Director also helped them purchase models, filmstrips, and overlays that were up-to-date.

When the district wouldn't build a greenhouse, the teachers removed light covers in a science storage room, put the lights on a timer, constructed a large framework to hold plant flats, and began growing plants where none grew before. The superintendent still wonders why they have tomatoes in early June! They also worked on instructional strategies to enhance and enliven their total curriculum.

Mike and Lynn taught a "summer science" program enrolling more than half of the science students. Using a school bus as a classroom students explored Northern Utah. This experience helped the students understand science, stimulating their interest. Collecting rocks, minerals, and fossils, exploring natural caves, studying the flora and fauna of Cache Valley, hiking to world record trees like Old Juniper and Limber Pine, studying the geology of the area and fish populations in the Logan and Blacksmith Fork River were just a few of the educational summer science activities. In essence, students became involved in science and the science processes. They were no longer passive objects in an important facet of life. Soon, a yearly field trip to Hansen Planetarium and the Museum of Natural History in Salt Lake City became part of the regular school program.

A real support and asset to the program came in 1976 with the addition of Randy Christensen to the science staff. He has provided an important element of success. Working together the three teachers have seen their program evolve into a program to be proud of. For example, this last March some of our students, along with students from nine other schools, entered the Utah Power and Light Energy Contest for northern Utah and southern Idaho. Our students earned seven of the awards given.

Because of the many fields of science available for study and limited time, students do not cover every unit listed in the curriculum each semester. Instructors are free to alternate different units from year to year.

The next curriculum concern for the science staff involves "flexibility" with what is current in science and of interest to students. For example, in May 1981, when Mt. Saint Helen's blew its top the focus of instruction shifted quickly to vulcanology. The space shuttle has provided interest and excitement for all the students. The curriculum is already being planned for 1985 and 1986 when science will have a banner year in astronomy with the launch of the space telescope, the arrival of Voyager II to Uranus, and the long awaited return of Halley's Comet.

Major goals of the science curriculum at South Cache Junior High School include making science relevant to real life situations and giving the students a "hand on approach."

In seventh grade, we have only one semester. Devoting this to biology, we emphasize the physical conditions necessary for life. This leads easily to photosynthesis, genetics and reproduction, and evolution. We also study classifications, the chemical basis of life, and many classical concepts in ecology.

LIFE SCIENCE

7th Grade Science - 1 semester

Units of Study

* What is Life and the Study of Life Processes

* Needs of Living Things
* Physical Conditions Necessary for Life
* Cells and Organization of Life
* Mitosis -- Cell Division
* Reproduction of Life
* Heredity
* Classification of Living Organisms
* Simple Organism
* Plants
* Animals
* Life in the Past
* Ecology of Life
* Science Learning Log
* Science Readings

PHYSICAL AND EARTH SCIENCE

Eighth grade, with two semesters of science, concentrates on general physical science the first semester and earth science the next. Students study the properties of matter, chemistry, mechanics, and energy, as well as concepts from traditional physics.

8th Grade Science - 1 semester

Units of Study

* What is Science?
  Science Processes
* Measurement and Science
* Chemistry
* Basic Physical Science
* Energy
  What is Energy? **Primary Energy Sources**
  Alternative Energy Sources for the Future
  Utah Power and Light Energy Contest
* Learning Log

* Science Readings

During the earth science semester, students cover the evolution of the earth, our atmosphere, rocks and minerals, weathering, and mountain building.

8th Grade Science - 1 semester

Units of Study

* What is Earth Science?
  What do Earth Scientists Do?
* Minerals-Crystals of the Earth
* Rocks and Their Changes
* Fossils - The Story Rocks Tell the Earth Through Time
* The Changing Earth
  Shaping the Land Ice on the Land - Glaciers
  Plate Tectonics
  Earthquakes
  Volcanoes
* Astronomy Unit
* Weather Unit
  The Atmosphere
  Water in the Air
  Winds and Wind Systems
  Storms Across the Continents
* Mapping and Earth Science
* Learning Log
* Science Readings

ENVIRONMENTAL SCIENCE CRITERIA

Ninth grade science, an elective, focuses on natural resources and their management, ecology, farming, and ranching, as well as hunting, mining, and pollution.

9th Grade Science - Elective Course

Units of Study

* Ecology and the Environment
* Ecosystems

* Energy
* Poisonous Substances in the Environment
* Animal Behavior
* Endangered Species
* Wildlife Special Unit
* Learning Log
* Science Readings

STRENGTHS AND WEAKNESSES

The teaching staff contributes to the strength of the program. Their experience and enthusiasm about teaching science cannot easily be replaced. Administrative support for the program at both the school and district level is exceptional. The materials and equipment available within the department are impressive reflecting the willingness of the administration to provide funding for an improved program. The curriculum is another strong point from the interest-catching demonstrations of the first school days to the completed students' notebooks in which they take such pride.

As instructors we realize that any program can be improved. We strive toward that goal. Facilities available for teaching science could be improved, making our science classrooms better designed for teaching science. Class size presents a problem, though one not unique to the science classroom. Perhaps most important of all, science requirements for junior high students may be too low. We feel that one semester of 7th grade, two semesters of 8th grade, and 9th grade science as an elective, do not give students enough exposure to an extremely important subject. To truly develop science literacy, we need time for consistent exposure to relevant and useful science topics.

Now, the science program at South Cache in 1985 looks very different than it did in 1972. The focal point of the program is not the textbook, but the students and their science needs. We are pleased to say that students like science at South Cache Junior High School.

FACTORS CONTRIBUTING TO PROGRAM SUCCESS

At the core of any successful science program must be a teaching staff excited about science and eager to share that enthusiasm with students. To provide support for that program, it is necessary to have administrative help at the school and district level. The right kind of help makes possible the acquisition of those kinds of things which keep science from becoming a "textbook only" type of class into an experience that students remember for the rest of their lives.

We feel fortunate at South Cache Junior High School to have positive administrative help. Having acquired support systems necessary to make ours a very successful program, we can now implement a meaningful, hands-on experience for students.

For example, our extensive mineral and rock samples offer each student opportunities to study and learn the characteristics of over 50 specimens. Our life science program is equipped with a classroom set of new Swift microscopes. Living specimens give students the opportunity to observe under the microscope those things they otherwise would only read about. We feel our supply of audiovisual material -- overlays, filmstrips, and slides -- is very complete. While science knowledge constantly grows we strive to keep the material presented in class as current as possible. Through excellent slide programs our students follow the events of the Mt. Saint Helen eruption, learn about the Viking mission to Mars, or follow Voyagers I and II on their grand tour of the planets.

Reference materials provide invaluable support to our science program. At South Cache we use classroom sets of such books as National Geographic's **Our Universe** or **The Mammals** to provide additional reference sources. Through our science department subscriptions to such magazines as **Science World** are made available to the students. Realizing the importance of teachers keeping abreast of new scientific developments, other magazines such as **Biological Abstracts, Astronomy, Natural History, Audobon, Discover, Science 85, Geo, OMNI, Popular Science, Solar Age, National Geographic,** and **National Wildlife** are on our shelves as well. By making each classroom into a source of information, students become far more independent in their pursuit of knowledge and teachers learn a lot too.

In order to have such materials available to a program, both an understanding of their importance and a commitment to their purchase is necessary. We feel fortunate to have both from our administration. Our annual science budget is from $1500 to $1800 with the possibility of obtaining up to another $1,000 from district funding. In addition, during the 1984-85 school year a local scientific firm awarded our department over $4,000 to use as we see fit in purchasing science equipment for student use. This type of public support is invaluable in providing the best science experience possible. We are very proud of our science program at South Cache Junior High. Support systems help to make it an extremely successful one.

PROGRAM ADAPTABILITY

Several new science teachers, trained by cooperating teachers at South Cache Junior High School, have used South Cache's material to develop science programs in their new assignments. They have repeatedly returned to South Cache to obtain additional science curriculum. These new teachers are having successful teaching experiences in both large and small secondary schools. Using notebooks from students that have completed the program at South Cache has enabled some of these new teachers to transplant the whole science program to new schools.

We require each student to keep a neat and complete notebook in their science class. This notebook includes lecture notes, assignments, written projects, quizzes, major exams, and a special section for a learning log (daily journal of class activities and concepts learned) and one for newspaper articles related to science. Each unit of study in the notebook has a neatly done title page followed by a table of contents.

Our rationale for requiring notebooks as part of science education includes:

* Scientists keep written records of their work. Students of science also should learn this habit.

* Notebooks can help students develop writing and organizational skills.

* Science learning can be aided by the use of other intellectual disciplines, such as art, reading, and writing. These skills are used by each student in producing their notebooks.

* Good work in a notebook provides a student with a point of focus and pride.

* All kinds of creativity are possible in the creation of title pages related to the units of study. This can enhance creativity and provide possible extra credit for the gifted and talented students willing to do more than just the required assignments.

* A notebook provides students with something to refer back to in later years reminding them of an enjoyable science experience.

* Public relations are well served by a notebook. Parents enjoy seeing what their child has accomplished in science. Notebooks also provide a visible record of a student's science work for all interested to see.

EVALUATION

South Cache Junior High science students score well on the Comprehensive Tests of Basic Skills (CTBS). Our students scored above the national average for the school years 1975 through 1984. Our students eagerly enroll in more science.

Chapter 11: FIELD SCIENCE

By

Terry Logue and Dana Van Burgh, Jr.

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Casper, Wyoming, the largest city in the state, is home to about 80,000 residents. Casper lies in a unique geologic setting, with the bulk of the city falling between Casper Mountain to the south and the North Platte River to the north. North of the river are numerous active sand dunes and several soda or trona lakes. West of Casper are Emigrant Gap Anticline, Speas Dome and several small oil fields. About twenty miles to the east is the town of Glenrock, the Big Muddy Oilfield, Dave Johnson Power Plant, and an open pit coal mine. The Casper economy depends, to a large part, on mineral industry, agriculture, and tourism.

Our school district includes all of Natrona County including thirty-two elementary schools, three junior high schools, and two high schools in the Casper area, plus several rural schools and a combined elementary-secondary school at Midwest, Wyoming.

In 1964, Dana Van Burgh, Jr. and Ed Strube discussed the difficulties of teaching ninth grade earth science in the classroom. The length of the class period and the number of students involved made it difficult to take field trips, yet from their classroom windows they could see Emigrant Gap Anticline and Bessemer Mountain inviting student involvment. A summer program where students could actually climb across an anticline, key out plants, hunt fossils and see actual historical sites provided an alternative.

This program, including five, day-long field trips to areas of geological, biological, and historical interest has continued for twenty years. Students meet each morning and travel by school bus to the study areas and return home each night. Teaching done on the bus between sites facilitates student involvement at the study site. We study many diverse and interesting geological, biological, and historical sites:

* Sand dunes and prairie habitat north of Casper

* Casper Mountain
* Speas Fish Hatchery, Speas Dome and Bessimer Bend area
* Dave Johnston Power Plant and coal mine
* Alcova anticline, reservoir, and hydroelectric power plant

At the urging of Field Science students, a number of publications and spin-off programs have resulted.

OUR PROGRAM

Field Science can be taken by all students who have completed ninth grade earth science. Students must pay tuition for the course. Classes are limited to twenty students. All teaching is done in the field or on the bus.

Goals

In the twenty plus years that have elapsed since Field Science first started, the basic philosophy and teaching techniques have changed very little. The goal has been to give students a greater appreciation and respect for their natural environment. Part of this is accomplished by teaching some basic information about the areas visited. Students learn about the geology, biology, and history of the area. As the bus travels from site to site, students are encouraged to collect rocks, minerals, fossils, flowers, tree leaves and needles, insects, and other natural objects of interest. A number of identification keys and reference materials are carried on the bus to help students identify their finds. The teachers place a great emphasis on the natural ecology of the Casper area, pointing out of the problems caused by man and machines, and on the inter-relationships of geology, biology, and man. Particular emphasis is given to the relationships of rock formations and vegetation, vegetation and land use, past and present land use and geologic setting, geologic hazards and land use, topographic setting and vegetation, and wildlife populations and man.

Curriculum

Concepts and topics covered in the ninth grade earth science course including earth movements and structure, weathering and erosion, historical geology and stratigraphy provide the foundation of Field Science. The geologic maps of Casper Mountain and Alcova that are used in Field Science are the same ones used in the ninth grade earth science classes. The biological principles taught in Field Science include many studied in the high school biology classes. The plants , animals, rocks, minerals, and other natural objects discovered by students direct the teaching and learning. Some of the best teaching/learning situations result from the chance discovery of something in the field.

Instruction

A majority of the instruction occurs on the bus while traveling between stops. This provides more time for students to examine the natural features found at each location. Identification of student's collections

forms the basis for a part of the intruction. Teachers will provide help if students have trouble with identifications. The small teacher-student ratio allows for considerable individual or small group instruction. Tests are not given but students have ample opportunity to show what they have learned. Several times during the week students have to identify a flower correctly by using a flower key before they can get back on the bus or eat lunch. Students that have problems are given help so that everyone experiences success.

Whenever possible local experts are used explain natural resources. In addition to providing first hand information to the students, this provides them with contacts in the community that have an interest in natural science.

Teachers

Dana P. Van Burgh, Jr. has taught ninth grade earth science in the same room at Dean Morgan Junior High since 1957, He has a Bachelors of Art Degree in Geology from Coe College, a Master of Arts Degree in Science Education from Colorado State College, plus over ninety graduate hours including NSF Summer Institutes, workshops and courses dealing with science and science education.

Beecher E. Sturbe taught ninth grade earth science for thirteen years at Dean Morgan Junior High and has been teaching biology at Kelly Walsh High School for thirteen years. He has a bachelors of Science Degree in Education from the University of Wyoming, a Master of Science in Botany and Zoology from the University of Wyoming, and about fifty-five graduate hours in science, science education, and physical education.

Evaluation

Evaluation of Field Science is difficult from the standpoint of test scores or statistical analysis because formal tests are not given to students. An announcement from Mr. Sturbe that everyone has to key out a plant before they can eat lunch is as close as students come to a quiz. Most evaluation results from discussion between teachers during the day or at the end of a day's field trip. Typically teachers will discuss individual students in order to find ways to make them feel part of the group, or to help them with problems they are having. Many of the students involved in Field Science in the past have continued to show an interest in the programs. Changes or additions to the program have usually resulted from student requests. This interest and support of Field Science has resulted in the following programs:

Science History Loops

The first spin-off of Field Science was the Science History Loops. The Loops are five to seven day field trips which cover a larger portion of Wyoming or an adjoining state. About fifteen students, plus staff, travel by school bus, camping out or sleeping in school gymnasiums. Food for breakfast and lunch is purchased by the group and carried on the bus. Students purchase a hot meal in a restaurant for dinner. Biology, geology and history of these areas are studied on these field trips. Several Loops have been developed:

* Northwest Wyoming
* Northeast Wyoming
* Southwest Wyoming
* Southeast Wyoming
* Mineral Resources of Wyoming
* Montana Rockies
* Northeast Utah
* Green River Float Trip
* Yampa-Green River Float Trip

Advanced Field Science

An eight to ten day concentrated study at a historic ranch provides in-depth study of geology, biology, and history. Some specific topics that are "uncovered" include; astronomy, soil studies, mapping, bird watching, aquatic studies, basic photography, and live trapping to monitor small mammals in the area. Advanced Field Science also offers the unique experience of living in a ranch house without electricity or running water. The slower pace allows for reflection and introspection. Watching the sun set as the night hawks swoop and dive is a nightly ritual for many of the students.

Field Instructor Training Course

This course teaches students the special knowledge and necessary skills to be effective field assistants or instructors for Field Science or other similar programs. The course, offered as interest demands, meets during the regular school year. Both high school and college credit is available for participants.

Mobile Museum

In 1975, school bus number 14, which had been used for many years with the Field Science programs was retired from active duty and converted into the Mobile Museum. This program, inspired by a visit to the Anna Miller Mobile Museum in Newcastle on the Northeast Wyoming Loop, has been used to present programs to elementary students in Casper. Programs on spinning and weaving, fossils and rocks, animals, insects, and birds have been presented by volunteers. One half of the class receives instruction on the bus while the other half views a slide-tape presentation or performs an activity in the classroom. Currently the program is inactive.

Publications

The publications grew out of a desire to provide students with sources of information about some of the areas that were visited on Field Science. They have also provided an opportunity for students to do original research, develop a theme and become "published," and have been a means of expanding the Field Science concept to others.

The first publication was **A Field Guide to the Alcova Area.** This eighty page guide, based on a road log, includes geologic maps, cross-sections, annota photographs and information on the history, geology, and biology of the area. The Field Guide was done to assist students who wanted to take their family back to the areas they had visited.

Sketches of Wyoming combines the effort of numerous artists and writers interested in preserving a little of Wyoming's history. Contributers ranged in age from junior high to retired. The publication includes line drawings of historical sites with appropriate prose and poetry.

A Field Guide to the Casper Mountain Area follows the format used in the Alcova Field Guide, using the road log to organize the presentation of biology, geology, and history of the Casper Mountain area. In addition, this publication makes use of many line drawings of plants and animals that would not normally be included because photographs are not available. A two page color center spread of plants and animals of Casper Mountain highlights this publication.

The **Monograph** series is an ongoing effort to publish information about the geologic, biologic, and historic sites of the Casper area. Written by students, these four page pamphlets include such titles as: Goose Egg Ranch House, Ayres Natural Bridge, Casper's City Halls, Cole Creek Train Wreck, and Record in Stone and Bone.

The Wyoming Field Science Foundation, a non-profit corporation set up by a local business man, pay the cost of publishing all of these written works. All profits from these publications are returned to the Wyoming Field Science Foundation.

Lee McCune Braille Trail

The Braille Trail, a nature trail for the visually handicapped, resulted from a Science-History Loop which visited a Braille Trail in Colorado. It was named Wyoming's first National Recreational Trail by Secretary of the Interior Thomas S. Kleppe in June of 1976. Financed by the Casper Mountain Lions Club and private donations, the trail was designed and built under the direction of Beecher E. Strube. The Lions, Field Science students, and other interested people helped build the trail. It includes a series of 36 plaques in braille and print, connected by a rope walkway. The trail, over one-third of a mile long, covers a variety of habitats from marsh to rock outcrops to forest.

One-Day Science History Loops

As an effort to involve working members and families of the community, One-Day Science History Loops, began in the summer of 1977. Following the same format at the other loops, this program includes interesting areas of the Old Bozeman Trail and the Bridger Trail which are within a comfortable radius of Casper. An "Expert-for-the-day" serves as a guest lecturer or instructor.

Sierra Madre Field Science

In the summer of 1979, co-owners offered The Wyoming Field Science Foundation use of the Sierra Madre Ranch, near Saratoga, Wyoming, as a Field Science camp. The week long program included detailed studies similar to those done at Advanced Field Science, combined with field trips to clear cut areas, the Snowy Range Mountains, and the Grand Encampment Mining District

Elementary School Field Science

Elementary school teacher Karen Fuller participated in Field Science and several advanced courses and then developed a program for primary level children. This course is just three days in length and the days are shorter than for the secondary level. Some art is added to the science and history.

Field Science for Teachers

In response to teacher requests and in an effort to expand outdoor instruction and an awareness of the Casper area a Field Science course for teachers was added to the offerings. Credit is provided by the University of Wyoming.

Course content is approximately the same as for secondary students with the addition of some teaching techniques and background information.

STRENGTHS AND WEAKNESSES

Goals

Based on the response of students who have taken the course, Field Science fulfills most of its goals. A number of Field Science students have gone on to careers in science education, wildlife management, geology, botany, zoology, or related fields. One former student is presently the director of the Teton Science School. Field Science emphasizes direct contact with materials being studied. The course does a lot to pomote environmental awareness and should have some lasting effect on students' environmental decisions. Field Science provides an excellent example of interdisciplinary studies in action and brings students into contact with people working in science related careers.

Curriculum

Field Science provides some excellent illustrations of geologic concepts and principles that students have been exposed to in their ninth grade earth science classes. It also gives students an excellent introduction to taxonomy and ecology for their biology classes and reviews some of the local history they studied in fourth grade.

The small student-teacher ratio provides for a wide range of activities based on individual differences.

Instruction

The concreate experiences and "hands-on" learning which occurs during field trips forms the foundation of the course. The order in which the sites are visited has little bearing on the teaching. The sequence has been changed from time to time in the past with no discernable change in the results. The important factor in the instruction is to provide students with basic terms and procedures and build on this foundation by repetition and addition of information as the course progresses. Many of the students feel that one week is not enough time to learn all that they want to know. The advanced courses have helped to compensate for this shortcoming.

Teachers

The Field Science teachers work well together. They are adept at working with students and obviously enjoy what they do. They are frequently visited or contacted by former students to discuss Field Science experiences and to share new experiences with them. All the teachers have a very broad background in science. Among them, there is little in the field of science that has not been studied either formally or informally. Planning for Field Science and other advanced programs leaves little to chance. Plans for a program begin at least six months before it takes place. Lack of instructors to cover all the programs and projects in Fields Science has been relieved by the addition of Dr. Terry Logue and Cheryl Reade to the staff.

Evaluation

What appears to be a major weakness of Field Science may also be one of it's strengths. No formal tests are given to students participating in the course. This prevents any analysis of grades or tests scores to measure specific gains. There are no attitude surveys administered to see if students have changed their attitudes about natural science. However, the absence of any tests makes Field Science a non-threatening experience which relies on the student's self-motivation to accomplish the goals. The teachers believe that tests would change the entire complexion and direction of Field Science and would tend to make it just another science class. Evaluation of the course based on teacher observation and student response to the field trips occurs constantly. Formal evaluation of the program by the school administration has not ocurred.

SUCCESS OF THE PROGRAM

Time, energy, and resourcefulness of the teachers involved are the major factors that have contributed significantly to the success of Field Science. Support and encouragement of students and friends and the financial backing of the Wyoming Field Science Foundation and the school district help keep the program going.

The greatest costs includes the publication of the field guides, related information sheets, and annotated photo sheets, but the tuition pays the cost of these materials. The sale of publications to the public always recovers the initial cost of publications and usually provides a profit to the Field Science Foundation.

DUPLICATION OF PROGRAM

Any school district with enthusiastic, knowledgeable science teachers and a school bus should be able to easily duplicate the basic Field Science program.

EVALUATION

The summer of 1983 will mark the twentieth year of Field Science. Over six hundred students have participated in the course and about one-fourth of these students have also been involved in one or more of the other Field Science programs. The letters and responses of students, the comments of people that have observed Field Science in action, the cooperation of individuals that help with Field Science year after year, and the feeling that it's working, provide an informal evaluation of the program. Seeing former students give the teachers a hearty handshake or a big hug tells more about the success of the program than reams of test results.

Chapter 12: MIDDLE SCHOOL/JUNIOR HIGH SCIENCE: A SYNTHESIS AND CRITIQUE

By

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Throughout this volume authors stress the uniqueness of the students they teach. They emphasize the uniqueness in their age, attitudes, physical and mental development, and immediate and long-range needs. Over and over again the authors point out that these students are in a concrete or transitional stage as they are developing from a somewhat dependent mode into a more independent one. Recognizing these factors of adolescents, developers of the programs in this volume have created many unique and exemplary science programs.

Equally important, the Task Force on Excellence in Middle/Junior High Science has established a set of criteria which are very informative for someone wishing to evaluate an existing program or create a new one. These criteria, expounded upon in Chapter One, include the five broad categories of goals, curriculum, instruction, teachers, and evaluation.

GOALS

Middle/Junior High science students should develop skills in inquiry and problem-solving.

In the Seventh Grade Life Science program at Scottsburg Junior High school (Chapter Two) students rehabilitate animals, making decisions about care, feeding, and what to do with particular injured animals. These are very real-world problems they are solving and wrong answers lead to serious results. Chapter Five, the PRIS2M program in Rochester, New York, emphasizes inquiry and problem solving in a program designed to increase the number of minority students capable of becoming successful engineers.

Students gain interdisciplinary science knowledge.

While most environmental science programs focus on the life sciences, in the Environmental Physical Science program of Lower Moreland Middle School (Chapter Six) students study ecology from a physical science perspective. In the process, students become more aware of the living aspects of the environment and their relationships with physical dimensions.

Students should gain a positive attitude from their experience in school science.

Recognizing that student attitudes arise from their success or failure with materials as well as their sense of excitement, all of these exemplary programs have taken special care to see that attitudes are influenced positively. The Rochester Science Program (Chapter Three), for instance, is one-third laboratory, one-third problem solving and class discussion, and one-third teacher presentation rich in demonstrations, visual materials, and applications of science. As in many of the programs, the Rochester Science Program emphasizes applications of science and offers many options for students. To help insure student understanding of teacher presented materials, student use hand signals as a quick way to indicate their understanding of a single concept.

The South Cache science program (Chapter Ten) was designed especially to be a stimulating science program focusing on the needs of students. Developers of this program wanted students to become independent learners. In doing so, the outdoors becomes a laboratory, incorporating current events and hands-on activities into a science course where students can be successful and value what they are doing. Not surprisingly, South Cache students take many science courses beyond those required.

Students should relate science to themselves and to life in general.

The Summer Field Science program (Chapter Eleven) takes students on significant field trips to areas of geological, biological, and historical interest. Particular attention is given to the interrelationships of science and man and the problems caused by man and his machines. Basic concepts from 9th grade earth science as well as 10th grade biology are stressed. Aspects of this program also allow students to participate in concentrated study at a historical ranch and in developing field trips and nature trails themselves.

CURRICULUM

The curriculum should focus on the processes of inquiry.

While all these programs stress inquiry they each have developed different approaches. Chapter Four, Laboratory At The Zoo, places students in a community setting where their inquiry focuses on the nature and problems of zoo animals. Here, students work with the animals and with people trying to explain basic concepts.

Topics covered should be from many science areas.

Almost uniformly, these ten exemplary programs present the broad field of science in general. Even programs like Environmental Physical Science (Chapter Six) manage to include life science in what could easily be a fairly traditional physical science program. And, in programs like Seventh Grade Life Science (Chapter Two), rather than being an animal hospital center, students study the effect of organisms on the environment and man's responsibility for the physical as well as the biological world.

Even where programs are divided into discrete courses such as "life science" topics covered seem to include both the life and physical sciences.

Practical applications of science should be a central focus.

What is more practical than helping to rehabilitate injured animals? Students in the Scottsburg, Indiana program certainly feel they are doing something useful and can easily see the results of their good work. The PRISM program (Chapter Five) recognizes that children work best when trying to find and answer problems they themselves have chosen. Their problems often are chosen from the local community and environment and are tackled in a practical manner using their recently developed process skills.

The curriculum must interrelate science and society.

An amazing number of these programs cite examples of students going out into the community, identifying and solving problems. Others take significant advantage of current events and other happenings. The South Cache science program (Chapter Ten) finds teachers changing units yearly as they cover new current events and issues. As they teach topics including ecology, natural resources, farming, hunting, ranching, and pollution, teachers cannot help but include current topics in their teaching.

The curriculum must allow for the needs of predominately concrete operational students.

Without exception, these programs recognize the needs and problems of adolescent students. Focusing heavily on student participation, these ten science programs emphasize laboratory work, real-world identification and solution of problems, small group class discussions, and very little lecture. The success of these programs is evident; all programs claim large numbers of students going on and taking additional optional sciences in the high school.

The curriculum must allow for student input and independence.

Chapter Two (7th Grade Life Science) has students making very critical decisions about their injured animals. While not every program gives students opportunities to make literally life or death decisions, all of these programs allow student independence and decision making to some extent. This may be in the form of decisions on what to study, such as students in PRISM, and, at other times it may be decisions about their own understanding, such as in the Rochester Science Program.

The science curriculum must be interdisciplinary.

All of these exemplars emphasize the interdisciplinary nature of their programs. Some, such as Chapter Eight, the 5-8 General Science Program at E.T. Richardson Middle School, have built a program around a core of nationally developed, interdisciplinary materials supplemented by additional materials reflecting local needs and interests. Others, such as the Environmental Physical Science Program in Chapter Six, use traditional techniques of one discipline in studying problems in another. One way or the other, students in all of these programs find themselves studying the broad field of science, not just one relatively narrow discipline reflecting its own particular biases, techniques, and results.

An exemplary science curriculum includes aspects of the history and nature of science.

Although none of the programs approach the history and philosophy of science very directly, the nature of science and science literacy in general would seem to be important by-products of each. But, to truly meet the criteria set up by the Task Force on Finding Excellence in Middle/Junior High Science and to truly enhance scientific and technological literacy, middle/junior high science programs should allow students opportunities to delve into past learnings in science and how they came about, study personalities of science both past and present, and to approach science in a philosophical way, allowing them to develop a way of looking and a way of knowing.

INSTRUCTION

Teachers should use a variety of strategies, emphasizing concrete experiences.

Rather than merely talking about flowers and fossils or tree leaves and needles, the Field Science Program at C Y Junior High School and Dean Morgan Junior High School (Chapter Eleven) is a summer program emphasing field trips. To take advantage of the hands-on opportunities of being in the field, all teaching occurs on the bus as they are travelling. No written tests are given, as students are provided opportunities to demonstrate their knowledge. In Chapter Five, PRISM teachers are very cautious, wishing to present materials in a manner consistent with how adolescents learn. Then, they provide equally numerous opportunities for students to apply what they have learned from the highly manipulative, materials-intensive course.

Instruction should recognize variations in students' background.

Since all students must take the 9th Grade Earth Science course described in Chapter Seven, individual learning units were developed to help students with reading and mathematics difficulties. The Rochester Science Program (Chapter Three) also uses many locally developed learning packets where students get significant feedback as to the progress and depth of their understanding. Schools that take advantage of developing their own materials provide many opportunities for students of varying backgrounds to find success and happiness in the science classroom.

Instruction should take advantage of community resources.

Even though almost all of these programs take advantage of volunteers, local museums, field trips, and other community resources, some have gone even further. Chapter Four, the Laboratory At The Zoo, uses a rather large resource as a principal place and mode of instruction. Another, the 7th Grade Life Science program at Scottsburg, Indiana, rather than using community resources in a traditional manner has students lecturing to other teachers at the local, state, and national level on how to care for animals.

Instruction stresses social growth, value clarification, and self sufficiency as well as traditional science knowledge.

What could emphasize self-sufficiency more than a nature trail for the visually handicapped? As part of the Summer Field Science Program described in Chapter Eleven, students developed and other students use the Lee McCune Braille Trail as they find ways in which they too can learn about environmental awareness. And, as might be expected with an outdoor environmental program, values are given considerable attention.

Chapter Two, Seventh Grade Life Science, obviously focuses on the value of rehabilitating wounded animals and encourages students to examine their own values as they care for these injured organisms. And, students in PRISM cannot avoid values either as they study interrelationships between themselves and their environment and between science, technology, and society.

All of these programs allow students many opportunities to express their own opinions, to investigate problems of their own choosing, and to work to their very utmost capacity. In doing so, their own cognitive growth is assured but, perhaps equally as important, in working with other students their social growth is assured as well.

TEACHERS

The best teachers for middle/junior high science have preparation in science as a broad field and specific preparation in teaching science to early adolescents.

While all of the teachers mentioned specifically in these ten programs seem to have a broad background in science, most either do not mention specific preparation for teaching junior high aged students or talk of having been high school science teachers who moved to the lower grades. While these particular teachers perhaps have intuitively or systematically grasped what was necessary to teach these early adolescents, it would probably be worthwhile to create systematic inservice and preservice programs focusing on the needs, characteristics, and attributes of the middle/junior high school student. Perhaps one of the reasons these programs are exemplary is because their developers have taken these needs into account even without having had formal education about this age level.

Teachers must continue to update their knowledge of science and teaching.

In studying these programs and their teachers we gain an image of teachers who are continually taking college level science courses as they attempt to find more and more knowledge. But, we also see teachers who are reading, travelling, and talking to others. While they are getting much formal education they are also gaining much informal education by looking at their interactions with others and with the environment from the point of view of "how can I use this in my science classroom?"

Some programs have strong inservice components and others have developed informal components which probably have more power than many more formal inservice programs. For example, teachers in the PRIS2M program meet together before school each day as they have for years. In the process, their fifteen-minute-a-day inservice has led to numerous and profound changes and a definite philosophy among staff members.

Other programs mentioned specifically using students as a keen source of inservice development. As they work with and watch their students, these analytical teachers are gathering clues as they formatively evaluate themselves and their programs.

Teachers must self-evaluate.

In each of these ten programs authors speak of gathering feedback from students, other teachers, administrators, and the community. They use this feedback, comparing it to their goals, as they try to determine the next step in their strategy and in their program. This critical aspect of self-evaluation is very important for each program because they are striving hard to meet the needs of students as well as their own needs for a strong and innovative science curriculum.

Successful middle/junior high teachers improvise, adapt, and invent.

Chapter Eight, 5-8 General Science program, has taken a variety of nationally developed materials and adapted them to their own particular use at Richardson Middle School. In the process, they have included cooperative small groups, ideas from other studies, and team teaching. In addition, they have a variety of locally designed materials to enrich and expand their science program.

The Field Science program in Chapter Eleven was totally invented as were the nature trails on which the curriculum depends. These teachers have also written a number of books, monographs, and activities which are published and used widely throughout Wyoming. In addition, many are models for what could be done in other localities. And, they don't have to be expensive. The author of Chapter Two speaks proudly of not using local money for the program. In this program, all materials are gained through recycling of cast off and discarded objects, leading to a fully self-sufficient program.

In improvising, adapting, and inventing, these teachers are modeling the type of person they would like students to be. The very nature of improvisation and invention is consistent with the processes of science and its applications.

Teachers enjoy teaching in the middle/junior high and they relate well to students.

Over and over again, we found people describing themselves as really enjoying what they were doing and finding that they had something to offer students in this particular age range. In the process, these teachers are developing materials specifically for their students rather than trying to water down high school materials. The end result is students who want to take more science, who feel positive about science, and who are finding they can actually use their science even as middle/junior high school students.

EVALUATION

Evaluation should relate to goals in the affective, cognitive, and psychomotor domains.

As in many of the programs, students in Environmental Physical Science (Chapter Six) conduct activities which follow carefully the goals of the developers. As these goals go well beyond the cognitive, including the affective and psychomotor, so the activities include doing and valuing as integral components.

Evaluation Recognizes Individual Differences.

The mastery learning approach of Chapter Nine, Seventh Grade Life Science, provides all students with numerous opportunities for success. The Field Science program (Chapter Eleven) even offers opportunities for handicapped students to see how well they themselves have done. Time after time, these authors speak of meeting the needs of individual students and allowing students to progress as far as they can. And, their programs demonstrate this can be done.

Evaluation includes both process and product.

While the Field Science Program is emphasizing individual differences, they are also emphasizing both the building of nature trails and their use. We found no evidence among these exemplars of students conducting activities just for the sake of having an activity. We found these programs stressing cognitive outcomes and recognizing that as a result of these cognitive outcomes and the strategies used to develop them that students become deeply involved in the processes of investigation. In their evaluations, these authors take serious note of how students approach and solve problems, not just whether they can.

Administrators, teachers, peers, and community members are involved in the evaluation.

In almost every instance among these ten exemplary programs the community is very aware of their existence. By becoming highly visible in the community and by seeking community support, these programs are being evaluated continuously by non-traditional evaluators. It appears that program developers welcome outside evaluation. And, since many of these

programs involve team teaching in some way, peer evaluation also is a continual and ongoing effort.

Evaluation includes relevance to society.

With no hesitation, we can state easily that each and every one of these programs has been built around the goal of making science a more relevant factor in student life and of seeing that the relationship of science and society is an ever present theme in the classroom. These programs speak of evaluating programs and students based on how well they are able to find relationships, identify possible solutions, and take relevant social action.

AN ANALYSIS

We find it easy to commend these ten exemplary middle school/junior high science programs. Without any doubt they have taken seriously a set of goals and criteria similar to those developed by the Middle School/Junior High School Task Force on Developing Criteria for Excellence. That they have done this independently of each other and of the task force does much to validate the criteria themselves. Without any hesitation, we can confidently recommend these ten programs as models of what might be in curriculum development, as models of caring teachers and developers, and as models of how middle school/junior high school science students can take an active role in the learning of science and its relationship to our environment.

As all of these programs point out, they are programs in evolution. They have not reached their pinnacle of success and they are constantly looking for changes which might improve their ability to meet their goals. We have commended these exemplars for many fine innovations and successes. For improvement we have several suggestions from our analysis of these programs. These suggestions are based upon our perception of weaknesses which might be part of many of these programs.

While all of these programs stress inquiry, we would like to see more opportunities for students to independently identify problems to solve. In the process, we would like to see teachers creating an environment rich in issues, ideas, and materials, along with opportunities for students to make decisions, inquire, and find meaning for themselves.

Often, in describing their programs, authors indicate a well-organized program with carefully designed activities and materials. Rarely, however, do they speak clearly of the teaching strategies employed within their programs. They speak of wanting to encourage students but do not say how they will accomplish this. Perhaps they just do not communicate well about their strategies or, perhaps, their strategies are not well developed. If their strategies are not well developed, we would like to see them write more about such strategies, and if the strategies are not well developed, this is an obvious area of concern and need.

We would like to see more practical applications in each and every program. In many cases, there are few applications and in others the applications seem somewhat contrived. We would like to see students seeking serious applications of the ideas presented to them as well as the ideas they derive. Students must make decisions about how to make applications in real-world settings.

Although the community is involved in many of these programs we feel strongly that more community involvement will lead to even stronger programs. We would like to see more evidence of community resource leaders in the classroom and students being out in the community. School-community ties are strong and natural and must be taken advantage of. In doing so, both students and the community gain a closer understanding of each other and of their mutual importance in the overall scheme.

And, as a final note, we would like to see more systematic program evaluation, both formative and summative. As with many developers of innovative curricula, these developers have put their time into development and implementation rather than evaluation. While that may be appropriate in terms of achieving a needed success rate, systematic and powerful evaluation of such programs would make it easier to generalize from these programs and create new and better middle school/junior high science programs in other schools.

A SHORT SUMMARY

With these exemplary programs we now have a more powerful evidence that middle school/junior high teaching is not a wasteland but an area of fertile imagination on the part of teachers, curriculum developers, and students. We sincerely hope that this issue of the **Focus on Excellence** series will stimulate the development of additional curriculum in science and other school areas. We feel strongly that such improved curriculum in the middle school/junior high years will have significant impacts on both the elementary and upper secondary schools. We look forward to that happening.